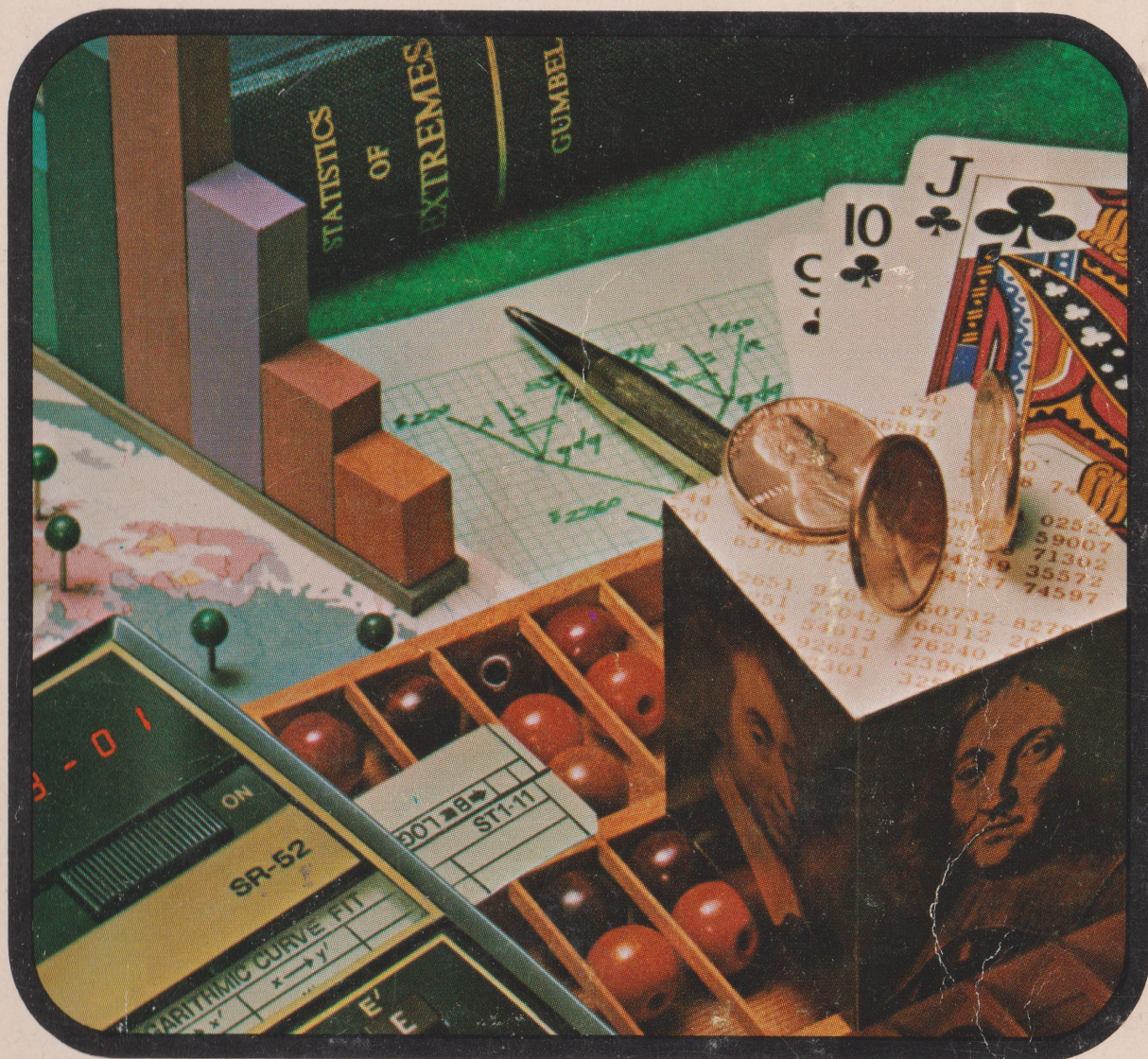


Texas Instruments

programmable calculator



Program Manual ST1

Statistics Library



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ADDENDUM

Dear Customer:

Please mark the following corrections in the Statistics Library Program Manual ST1:

PROGRAM	PAGE	SHOWN AS	CHANGE TO
ST1-03-1	15	196 47 *1'	196 87 *1'
ST1-05	25	218 18 C'	218 18 *C'
ST1-06	29	120 04 4	129 04 4
ST1-15	71	132 04 4	133 04 4
ST1-25	103	002 02 INV	002 22 INV
ST1-14	66-67		(see other side)

DO NOT RERECORD THE MAGNETIC CARDS. The prerecorded magnetic cards have been correctly recorded at the factory.

Change the first equation on page 18 to read:

$$U_{i+1} = 7^9(U_i \div 10^{10})(\text{Mod } 10^{10})$$

On page 65, the minus sign should be deleted from the display column in Step 6.

Note 2 on page 68 should be changed to read $|X| < 21.097$

ADDENDUM

SR-52 Program Manual ST1 Statistics Library

This manual was printed with an incorrect program listing for program ST1-14 Histogram Construction. DO NOT rerecord the magnetic card for this program. The correct program listing follows.

ST1-14

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 56 *rtn		028 29 *x!		056 00 0		084 01 1	
001 46 *LBL		029 46 *LBL		057 01 1		085 08 8	
002 14 D		030 65 X		058 60 *if flg		086 00 0	
003 50 *st flg		031 00 0		059 01 1		087 42 STO	
004 01 1		032 20 *1/x		060 55 ÷		088 00 0	
005 46 *LBL		033 86 *rset		061 94 +/—		089 00 0	
006 19 *D'		034 46 *LBL		062 46 *LBL		090 22 INV	
007 42 STO		035 29 *x!		063 55 ÷		091 50 *st flg	
008 01 1		036 65 X		064 36 *IND		092 01 1	
009 06 6		037 43 RCL		065 44 SUM		093 43 RCL	
010 94 +/—		038 01 1		066 00 0		094 01 1	
011 85 +		039 03 3		067 00 0		095 06 6	
012 43 RCL		040 20 *1/x		068 44 SUM		096 56 *rtn	
013 01 1		041 85 +		069 01 1		097 46 *LBL	
014 04 4		042 93 •		070 09 9		098 15 E	
015 95 =		043 05 5		071 65 X		099 01 1	
016 23 ln x		044 57 *fix		072 43 RCL		100 44 SUM	
017 70 *if err		045 00 0		073 01 1		101 00 0	
018 65 X		046 95 =		074 06 6		102 00 0	
019 43 RCL		047 22 INV		075 65 X		103 01 1	
020 01 1		048 52 EE		076 44 SUM		104 02 2	
021 06 6		049 52 EE		077 01 1		105 75 —	
022 75 —		050 22 INV		078 07 7		106 43 RCL	
023 43 RCL		051 52 EE		079 43 RCL		107 00 0	
024 01 1		052 57 *fix		080 01 1		108 00 0	
025 05 5		053 09 9		081 06 6		109 95 =	
026 95 =		054 42 STO		082 95 =		110 80 *if pos	
027 80 *if pos		055 00 0		083 44 SUM		111 59 *π	

*Denotes 2nd function key

PROGRAM LISTING

ST1-14

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 01 1		140 86 *rset		168 43 RCL		196 01 1	
113 42 STO		141 46 *LBL		169 01 1		197 09 9	
114 00 0		142 10 *E'		170 05 5		198 95 =	
115 00 0		143 43 RCL		171 95 =		199 56 *rtn	
116 46 *LBL		144 01 1		172 55 ÷		200 46 *LBL	
117 59 * π		145 03 3		173 01 1		201 18 *C'	
118 36 *IND		146 65 X		174 02 2		202 17 *B'	
119 43 RCL		147 43 RCL		175 95 =		203 65 X	
120 00 0		148 00 0		176 42 STO		204 43 RCL	
121 00 0		149 00 0		177 01 1		205 01 1	
122 55 ÷		150 85 +		178 03 3		206 07 7	
123 43 RCL		151 43 RCL		179 43 RCL		207 95 =	
124 01 1		152 01 1		180 01 1		208 94 +/-	
125 09 9		153 05 5		181 04 4		209 85 +	
126 85 +		154 95 =		182 56 *rtn		210 43 RCL	
127 43 RCL		155 56 *rtn		183 46 *LBL		211 01 1	
128 00 0		156 46 *LBL		184 16 *A'		212 08 8	
129 00 0		157 12 B		185 43 RCL		213 95 =	
130 95 =		158 42 STO		186 01 1		214 55 ÷	
131 57 *fix		159 01 1		187 09 9		215 43 RCL	
132 03 3		160 05 5		188 56 *rtn		216 01 1	
133 56 *rtn		161 56 *rtn		189 46 *LBL		217 09 9	
134 46 *LBL		162 46 *LBL		190 17 *B'		218 95 =	
135 11 A		163 13 C		191 43 RCL		219 56 *rtn	
136 57 *fix		164 42 STO		192 01 1		220 00	
137 09 9		165 01 1		193 07 7		221 00	
138 47 *CMs		166 04 4		194 55 ÷		222 00	
139 25 CLR		167 75 -		195 43 RCL		223 00	

*Denotes 2nd function key

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PREFACE

The Statistics Library includes this program Manual and 29 prerecorded magnetic cards. The programs in this library have been selected because of their common use by statisticians and other professionals who need rapid solutions to problems involving curve fits, distribution functions and general statistics.

Each program in the Statistics Library is identified by a program name and number which also appears on each magnetic card. For example, **BASIC STATISTICS FOR ONE OR TWO VARIABLES** is the name of the first program and the number is ST1-01... where ST1 identifies the Statistics Library and -01 identifies the first program in the Statistics Library. Some programs are in two parts and have two magnetic cards which must be run one at a time to obtain different but related information. ST1-03-1 identifies the first card of the third program in the Statistics Library which is **MEANS AND MOMENTS (1)**. The second card, **MEANS AND MOMENTS (2)**, is identified by ST1-03-2.

The Statistics Library programs are individually described in this manual. The general description of a program begins on a left-hand page, followed by sample problems, a pictorial of the applicable magnetic card, and complete user instructions. The user instructions list all the necessary steps to perform the specific program. The first step of the user instructions is **enter program** which should be performed according to the procedure on page one of this manual. Each program section also includes a program listing and identification of memory registers and flags used by the program. The program listing provides a backup source to check that the prerecorded program has been correctly read by the calculator.

If you have difficulties in running a program:

1. Be sure that the user instructions have been followed.
2. Refer to Maintenance and Service Information in the Owner's Manual to determine the type of trouble you are having.
3. Write the Consumer Relations Department at:

Texas Instruments Incorporated
P.O. Box 22283
Dallas, Texas 75222

or call Consumer Relations at 800-527-4980 (toll-free within all contiguous United States except Texas) or 800-492-4298 (toll-free within Texas). If outside contiguous United States, call 214-238-5461 (We regret that we cannot accept collect calls at this number).

ENTERING A PROGRAM

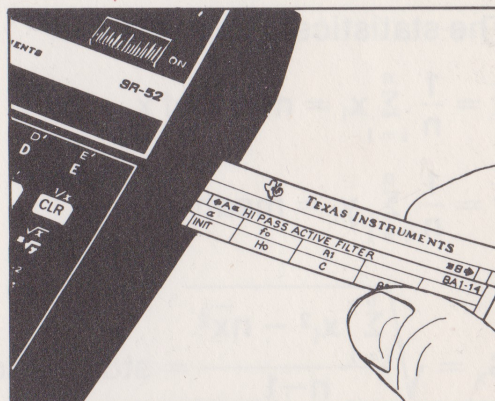
Use the following procedure each time you need to store the contents of a prerecorded magnetic card in the calculator. Use of this procedure is implied by the *Enter program* instruction in the user instructions of each program.

1. Select the proper magnetic card for the program to be run.

2. Read side **A** of the prerecorded card as follows:

CLR **2nd** **read** (Insert card **◀A▶**)

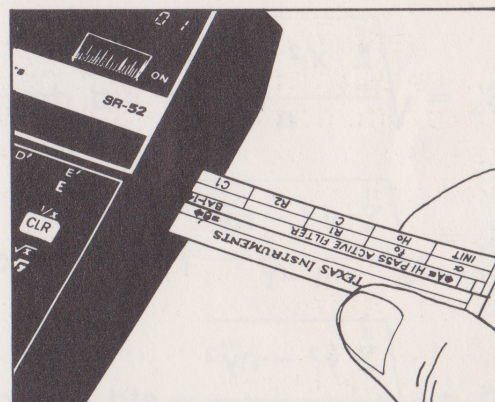
Do not restrict or hold the card after it is caught by the drive motor. The display is blank until the calculator has completed reading side A.



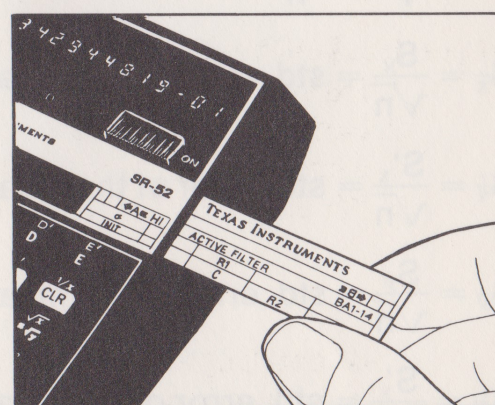
3. Remove the card from the left side of the calculator and read side **B** of the prerecorded card as follows:

2nd **read** (Insert Card **◀B▶**)

The display is blank until the calculator has completed reading side B.



4. Remove card from the left side of the calculator and insert into upper slot such that the A side of the card shows in the window above keys **A** through **E**.



5. If the display flashes immediately following step 2 or 3, repeat the procedure beginning with step 2.

CAUTION: Prerecorded magnetic cards may be damaged or altered if exposed to dust or foreign materials, permanent magnets, or electromagnetic fields (electric motors, power transformers, etc.).

BASIC STATISTICS FOR ONE OR TWO VARIABLES

This program calculates means, standard deviations, and standard errors of the mean for one or two variables, and covariance and correlation coefficient for two variables.

The input is a set of data points:

$$\{(x_1, y_1), (x_2, y_2), \dots (x_i, y_i), \dots (x_n, y_n)\}$$

in which the y_i 's may be omitted if only one variable is being used.

The statistics computed are:

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i = \text{mean of } x$$

$$\bar{y} = \frac{1}{n} \sum_{i=1}^n y_i = \text{mean of } y$$

$$S_x = \sqrt{\frac{\sum_{i=1}^n x_i^2 - n\bar{x}^2}{n-1}} = \text{std. dev. of } x \text{ by } n-1 \text{ method} \quad - \text{ items in sample}$$

$$S'_x = \sqrt{\frac{\sum_{i=1}^n x_i^2 - n\bar{x}^2}{n}} = \text{std. dev. of } x \text{ by } n \text{ method}$$

$$S_y = \sqrt{\frac{\sum_{i=1}^n y_i^2 - n\bar{y}^2}{n-1}} = \text{std. dev. of } y \text{ by } n-1 \text{ method}$$

$$S'_y = \sqrt{\frac{\sum_{i=1}^n y_i^2 - n\bar{y}^2}{n}} = \text{std. dev. of } y \text{ by } n \text{ method}$$

$$S_{\bar{x}} = \frac{S_x}{\sqrt{n}} = \text{std. error of the mean of } x \text{ by } n-1 \text{ method} \quad \text{means of samples}$$

$$S'_{\bar{x}} = \frac{S'_x}{\sqrt{n}} = \text{std. error of the mean of } x \text{ by } n \text{ method}$$

$$S_{\bar{y}} = \frac{S_y}{\sqrt{n}} = \text{std. error of the mean of } y \text{ by } n-1 \text{ method}$$

$$S'_{\bar{y}} = \frac{S'_y}{\sqrt{n}} = \text{std. error of the mean of } y \text{ by } n \text{ method}$$

$$S_{xy} = \frac{1}{n-1} \left[\sum_{i=1}^n x_i y_i - \frac{1}{n} \sum_{i=1}^n x_i \sum_{i=1}^n y_i \right] = \text{covariance of } x \text{ and } y \text{ by } n-1 \text{ method}$$

$$S'_{xy} = \frac{1}{n} \left[\sum_{i=1}^n x_i y_i - \frac{1}{n} \sum_{i=1}^n x_i \sum_{i=1}^n y_i \right] = \text{covariance of } x \text{ and } y \text{ by } n \text{ method}$$

$$r_{xy} = \frac{S_{xy}}{S_x S_y} = \frac{S'_{xy}}{S'_x S'_y} = \text{correlation coefficient of } x \text{ and } y$$

- NOTES: 1. The number of data points must be > 1 .
 2. This program may be used with the Linear Regression program (ST1-08) to determine additional statistics. Data points entered on either program may be used for the other. Do not initialize if data from the other program is being used.

Example: Calculate $\bar{x}$, $\bar{y}$, S_x , S'_x , S_y , S'_y , $S_{\bar{x}}$, $S'_{\bar{x}}$, $S_{\bar{y}}$, $S'_{\bar{y}}$, S_{xy} , S'_{xy} , r_{xy} for the data in the following table, then change the x and y values for $i = 5$ from (23, 17) to (5, 19) and find the new r_{xy} and S'_{xy} .

i	x_i	y_i
1	31	6
2	20.5	19
3	14	14
4	9	12.5
5	23	17
6	37	22
7	38	19.5
8	18	21
9	29	16

Enter	Press	Display	Comment
	2nd CMs		Initialize
31	A	1.	x_1
6	RUN	1.	y_1
20.5	A	2.	x_2
19	RUN	2.	y_2
14	A	3.	x_3
14	RUN	3.	y_3
etc.			
	B	24.38888889	compute $\bar{x}$
	2nd B'	16.33333333	compute $\bar{y}$
	C	10.07403152	compute S_x
	RUN	9.497888004	compute S'_x
	2nd C'	4.981214711	compute S_y
	RUN	4.696334268	compute S'_y
	D	3.358010507	compute $S_{\bar{x}}$
	RUN	3.165962668	compute $S'_{\bar{x}}$
	2nd D'	1.660404904	compute $S_{\bar{y}}$
	RUN	1.565444756	compute $S'_{\bar{y}}$
	E	10.85416667	compute S_{xy}
	RUN	9.648148148	compute S'_{xy}
	2nd E'	.2163006968	compute r_{xy}
23	2nd A'	8.	delete 23 (23, 17)
17	RUN	8.	delete 17 (23, 17)
5	A	9.	insert 5 (5, 19)
19	RUN	9.	insert 19 (5, 19)
	2nd E'	.0825567005	compute new r_{xy}
	E	5.006944445	compute new S_{xy}
	RUN	4.450617284	compute new S'_{xy}

 TEXAS INSTRUMENTS				
ST1-01		STATS FOR 1 OR 2 VARIABLES		
STATS FOR 1 OR 2 VARIABLES		ST1-01		
delete	$\bar{y}, n$	S_y, S_y'	$S_{\bar{y}}, S_{\bar{y}}'$	r_{xy}
x, y	$\bar{x}, n$	S_x, S_x'	$S_{\bar{x}}, S_{\bar{x}}'$	S_{xy}, S_{xy}'

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Initialize		2nd	CMS		
3	Enter Data	x_1	A			1
	If only one	y_1	RUN			1
	variable is used	x_2	A			2
	omit the y steps	y_2	RUN			2
4	To delete (x_i, y_i)	x_i	2nd	A'		
		y_i	RUN			
5	Compute outputs		B			$\bar{x}$
			RUN			n
	All outputs except		2nd	B'		$\bar{y}$
	those obtained by		RUN			n
	pressing run, may		C			S_x
	be obtained in		RUN			S'_x
	any order. Outputs		2nd	C'		S_y
	obtained by pressing		RUN			S'_y
	run must be		D			$S_{\bar{x}}$
	obtained immediately		RUN			$S'_{\bar{x}}$
	following the		2nd	D'		$S_{\bar{y}}$
	corresponding		RUN			$S'_{\bar{y}}$
	keypush shown.		E			S_{xy}
			RUN			S'_{xy}
			2nd	E'		r_{xy}

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 00 0		056 56 *rtn		084 44 SUM	
001 11 A		029 56 *rtn		057 46 *LBL		085 00 0	
002 42 STO		030 42 STO		058 16 *A'		086 04 4	
003 00 0		031 00 0		059 95 =		087 40 *x ²	
004 01 1		032 02 2		060 94 +/-		088 94 +/-	
005 44 SUM		033 44 SUM		061 42 STO		089 41 GTO	
006 00 0		034 00 0		062 00 0		090 32 sin	
007 03 3		035 04 4		063 01 1		091 46 *LBL	
008 40 *x ²		036 40 *x ²		064 44 SUM		092 12 B	
009 44 SUM		037 46 *LBL		065 00 0		093 43 RCL	
010 00 0		038 32 sin		066 03 3		094 00 0	
011 06 6		039 44 SUM		067 40 *x ²		095 03 3	
012 46 *LBL		040 00 0		068 94 +/-		096 46 *LBL	
013 34 tan		041 07 7		069 44 SUM		097 33 cos	
014 43 RCL		042 43 RCL		070 00 0		098 65 X	
015 00 0		043 00 0		071 06 6		099 43 RCL	
016 00 0		044 01 1		072 02 2		100 00 0	
017 30 *√x		045 65 X		073 94 +/-		101 00 0	
018 42 STO		046 43 RCL		074 44 SUM		102 20 *1/x	
019 00 0		047 00 0		075 00 0		103 54)	
020 08 8		048 02 2		076 00 0		104 56 *rtn	
021 01 1		049 95 =		077 51 SBR		105 43 RCL	
022 44 SUM		050 44 SUM		078 34 tan		106 00 0	
023 00 0		051 00 0		079 56 *rtn		107 00 0	
024 00 0		052 05 5		080 42 STO		108 56 *rtn	
025 25 CLR		053 43 RCL		081 00 0		109 46 *LBL	
026 43 RCL		054 00 0		082 02 2		110 17 *B'	
027 00 0		055 00 0		083 94 +/-		111 43 RCL	

*Denotes 2nd function key

REGISTERS

00 n	05 $\sum x_i y_i$	10	15
01 x_i	06 $\sum x_i^2$	11	16
02 y_i	07 $\sum y_i^2$	12	17
03 $\sum x_i$	08 $\sqrt{n-1}$	13	18
04 $\sum y_i$	09	14	19

FLAGS

0	1	2	3	4
---	---	---	---	---

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 00 0		140 43 RCL		168 13 C		196 00 0	
113 04 4		141 65 X		169 41 GTO		197 08 8	
114 41 GTO		142 43 RCL		170 42 STO		198 40 *x ²	
115 33 cos		143 00 0		171 46 *LBL		199 95 =	
116 46 *LBL		144 08 8		172 19 *D'		200 56 *rtn	
117 13 C		145 46 *LBL		173 18 *C'		201 65 X	
118 43 RCL		146 42 STO		174 41 GTO		202 43 RCL	
119 00 0		147 55 ÷		175 42 STO		203 00 0	
120 06 6		148 43 RCL		176 46 *LBL		204 08 8	
121 75 -		149 00 0		177 15 E		205 40 *x ²	
122 53 (		150 00 0		178 43 RCL		206 55 ÷	
123 12 B		151 30 *√x		179 00 0		207 43 RCL	
124 46 *LBL		152 95 =		180 05 5		208 00 0	
125 24 CE		153 56 *rtn		181 75 -		209 00 0	
126 40 *x ²		154 41 GTO		182 43 RCL		210 95 =	
127 65 X		155 43 RCL		183 00 0		211 56 *rtn	
128 43 RCL		156 46 *LBL		184 03 3		212 46 *LBL	
129 00 0		157 18 *C'		185 65 X		213 10 *E'	
130 00 0		158 43 RCL		186 43 RCL		214 15 E	
131 54)		159 00 0		187 00 0		215 55 ÷	
132 30 *√x		160 07 7		188 04 4		216 53 (	
133 55 ÷		161 75 -		189 55 ÷		217 53 (	
134 43 RCL		162 53 (		190 43 RCL		218 13 C	
135 00 0		163 17 *B'		191 00 0		219 55 ÷	
136 08 8		164 41 GTO		192 00 0		220 53 (	
137 95 =		165 24 CE		193 95 =		221 53 (	
138 56 *rtn		166 46 *LBL		194 55 ÷		222 18 *C'	
139 46 *LBL		167 14 D		195 43 RCL		223 56 *rtn	

*Denotes 2nd function key

PERMUTATIONS AND COMBINATIONS

For given n and r where $n \geq r \geq 0$, the following are calculated.

$$\text{Permutations: } P_r^n = \frac{n!}{(n-r)!} = n \cdot (n-1) \cdot \dots \cdot (n-r+1)$$

$$\text{Combinations: } C_r^n = \frac{n!}{r!(n-r)!}$$

- NOTES: 1. After an n, r pair has been entered, either or both may be changed for a new calculation.
2. $P_0^n = C_0^n = 1$
3. Error indications
- For $r > n$, the display flashes 9.999999999 99.
 - The display will flash 9.999999999 99 in case of overflow in the calculation.
 - For negative entries, the absolute values will be used.
 - For non-integer entries, the rounded integer value will be used.

Example: Find the number of permutations of 60 items taken 5 at a time and the number of combinations of 120 items taken 5 at a time.

Enter	Press	Display	Comment
	E		Initialize
60	A	60.	n
5	B	5.	r
	C	655381440.	$P_5^{(60)}$
120	A	120.	new n
	D	190578024.	$C_5^{(120)}$

 TEXAS INSTRUMENTS				
ST1-02 PERMUTAT'NS & COMBINAT'NS				
ST1-02 PERMUTAT'NS & COMBINAT'NS				
n	r	P	C	INIT

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Initialize		E			
3	Enter n ($0 \leq n$)	n	A			integer(n)
4	Enter r ($0 \leq r \leq n$)	r	B			integer(r)
5	Calculate $P_r^{(n)}$		C			$P_r^{(n)}$
6	Calculate $C_r^{(n)}$		D			$C_r^{(n)}$

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 56 *rtn		028 44 SUM		056 00 0		084 18 *C'	
001 46 *LBL		029 00 0		057 52 EE		085 42 STO	
002 88 *2'		030 04 4		058 95 =		086 00 0	
003 43 RCL		031 58 *dsz		059 57 *fix		087 00 0	
004 00 0		032 88 *2'		060 09 9		088 43 RCL	
005 04 4		033 43 RCL		061 22 INV		089 00 0	
006 49 *PROD		034 00 0		062 52 EE		090 01 1	
007 00 0		035 03 3		063 80 *if pos		091 42 STO	
008 03 3		036 86 *rset		064 89 *3'		092 00 0	
009 43 RCL		037 46 *LBL		065 94 +/-		093 04 4	
010 00 0		038 11 A		066 46 *LBL		094 75 -	
011 03 3		039 10 *E'		067 89 *3'		095 43 RCL	
012 70 *if err		040 42 STO		068 56 *rtn		096 00 0	
013 78 *5'		041 00 0		069 46 *LBL		097 02 2	
014 60 *if flg		042 01 1		070 13 C		098 95 =	
015 01 1		043 86 *rset		071 50 *st flg		099 22 INV	
016 00 0		044 46 *LBL		072 01 1		100 80 *if pos	
017 02 2		045 12 B		073 46 *LBL		101 78 *5'	
018 06 6		046 10 *E'		074 14 D		102 42 STO	
019 43 RCL		047 42 STO		075 25 CLR		103 00 0	
020 00 0		048 00 0		076 01 1		104 05 5	
021 00 0		049 02 2		077 42 STO		105 43 RCL	
022 22 INV		050 86 *rset		078 00 0		106 00 0	
023 49 *PROD		051 46 *LBL		079 03 3		107 01 1	
024 00 0		052 10 *E'		080 43 RCL		108 75 -	
025 03 3		053 22 INV		081 00 0		109 07 7	
026 01 1		054 52 EE		082 02 2		110 00 0	
027 22 INV		055 57 *fix		083 90 *if zro		111 95 =	

*Denotes 2nd function key

REGISTERS

00 Counter	05 n - r	10	15
01 n	06	11	16
02 r	07	12	17
03 → answer	08	13	18
04 n → n - 1	09	14	19

FLAGS

0	1 Used	2 Used	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 80	*if pos	140 00 0		168 75 -		196 00	
113 77	*4'	141 03 3		169 43 RCL		197 00	
114 43	RCL	142 46 *LBL		170 00 0		198 00	
115 00 0		143 79 *6'		171 02 2		199 00	
116 01 1		144 43 RCL		172 95 =		200 00	
117 29	*x!	145 00 0		173 80 *if pos		201 00	
118 55	÷	146 03 3		174 88 *2'		202 00	
119 43	RCL	147 86 *rset		175 50 *st flg		203 00	
120 00 0		148 46 *LBL		176 02 2		204 00	
121 05 5		149 78 *5'		177 43 RCL		205 00	
122 29	*x!	150 25 CLR		178 00 0		206 00	
123 95 =		151 20 *1/x		179 05 5		207 00	
124 42	STO	152 86 *rset		180 42 STO		208 00	
125 00 0		153 46 *LBL		181 00 0		209 00	
126 03 3		154 18 *C'		182 00 0		210 00	
127 60	*if flg	155 01 1		183 41 GTO		211 00	
128 01 1		156 95 =		184 88 *2'		212 00	
129 79	*6'	157 86 *rset		185 46 *LBL		213 00	
130 43	RCL	158 46 *LBL		186 15 E		214 00	
131 00 0		159 77 *4'		187 47 *CMs		215 00	
132 03 3		160 60 *if flg		188 86 *rset		216 00	
133 55	÷	161 01 1		189 00		217 00	
134 43	RCL	162 88 *2'		190 00		218 00	
135 00 0		163 43 RCL		191 00		219 00	
136 02 2		164 00 0		192 00		220 00	
137 29	*x!	165 05 5		193 00		221 00	
138 95 =		166 90 *if zro		194 00		222 00	
139 42	STO	167 18 *C'		195 00		223 00	

*Denotes 2nd function key

MEANS AND MOMENTS

For a given set of input data, $\{x_1, x_2, \dots, x_n\}$, with associated frequencies, $\{f_1, f_2, \dots, f_n\}$ (for grouped data), the following means, moments, and skewness and kurtosis of distribution are calculated. If $f_i = 1$ for all i , the calculations are for ungrouped data, otherwise for grouped data.

Means

$$\text{Arithmetic} = A = \frac{1}{N} \sum_{i=1}^n f_i x_i$$

$$\text{Harmonic} = H = N / \sum_{i=1}^n \frac{f_i}{x_i}$$

$$\text{Geometric} = G = \left(\prod_{i=1}^n x_i^{f_i} \right)^{1/N}$$

$$\text{Generalized} = M(t) = \left(\frac{1}{N} \sum_{i=1}^n f_i (x_i)^t \right)^{1/t}$$

Moments

$$m_1 = A = \frac{1}{N} \sum_{i=1}^n f_i x_i$$

$$m_4 = \frac{1}{N} \sum_{i=1}^n f_i (x_i - A)^4$$

$$m_2 = \frac{1}{N} \sum_{i=1}^n f_i (x_i - A)^2$$

$$\text{Kurtosis of distribution} = \frac{m_4}{(m_2)^2}$$

$$m_3 = \frac{1}{N} \sum_{i=1}^n f_i (x_i - A)^3$$

$$\text{Skewness of distribution} = \frac{m_3}{(m_2)^{3/2}}$$

$$N = \sum_{i=1}^n f_i \quad n = \text{Number of different groups}$$

- NOTES:
1. The initialization routine assumes a frequency of 1 and $t = 1$.
 2. The value of t may be changed before any x_i 's are entered, if changed after any x_i , $M(t)$ will be meaningless.
 3. For grouped data if $f_i = f_{i-1}$, it need not be entered.
 4. A negative frequency will cause the next x entered to be deleted $|f|$ times.
 5. A negative x will cause the geometric and generalized means to be invalid.

Error Indications:

A frequency or t of 0 will cause the display to flash 9.99999999 99 and the old value to be retained.

Example: The ungrouped ($f_i = 1$) data $\{x_i = 1.1, 2.3, 4.7, 3.5, 1.8, 2.9\}$ yields the following: $A = 2.716666667$, $G = 2.451843924$, $H = 2.187595899$, $m(1) = 2.716666667$; $m_2 = 1.368055556$, $m_3 = .5367592591$, $m_4 = 3.903019215$; kurtosis of distribution = 2.085418497, skewness of distribution = .3354470243

References: *Handbook of Mathematical Tables and Formulas*, R. S. Burington, McGraw-Hill, Fourth Edition, 1965, p. 164. *International Dictionary of Applied Mathematics*, W. F. Frierberger, D. Van Nostrand, 1960.

 TEXAS INSTRUMENTS				
1-03-1LS		1) MEANS & MOMENTS (1)		
←A		MEANS & MOMENTS (1)		
A	G	H	M(t)	
x → Σf	f	t	del x	INIT

 TEXAS INSTRUMENTS				
2-03-1LS		2) MEANS & MOMENTS (2)		
←A		MEANS & MOMENTS (2)		
A	G	H	M(t)	
m2	m3	m4	kurt	skew

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program ST1-03-1					
2	Initialize		E			1.
3	Enter t (for gen. mean)	$t \neq 0$	C			t
4	Enter data					
	a. for grouped data,					
	ent. f_i if $f_i \neq f_{i-1}$	$f_i \neq 0$	B			f_i
	b. enter x_i	x_i	A			Σf
	repeat a and b for each i					
5	Delete data					
	a. for grouped data,					
	enter f_i if $f_i \neq f_{i-1}$	$f_i \neq 0$	B			f_i
	b. enter x_i to be deleted	x_i	D			corrected Σf
6	Calculate					
	a. arithmetic mean		2nd	A'		A
	b. geometric mean		2nd	B'		G
	c. harmonic mean		2nd	C'		H
	d. generalized mean		2nd	D'		M(t)
7	Enter Program ST1-03-2					
8	Calculate					
	a. second moment		A			m_2
	b. third moment		B			m_3
	c. fourth moment		C			m_4
	d. kurtosis		D			kurtosis
	e. skewness		E			skewness
	f. means, see step 6					

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 45 y^x		056 43 RCL		084 00 0	
001 11 A		029 43 RCL		057 00 0		085 05 5	
002 42 STO		030 00 0		058 02 2		086 55 $\div$	
003 00 0		031 02 2		059 65 X		087 43 RCL	
004 04 4		032 95 =		060 44 SUM		088 00 0	
005 65 X		033 49 *PROD		061 00 0		089 01 1	
006 43 RCL		034 00 0		062 09 9		090 95 =	
007 00 0		035 06 6		063 43 RCL		091 42 STO	
008 02 2		036 43 RCL		064 00 0		092 01 1	
009 95 =		037 00 0		065 04 4		093 02 2	
010 44 SUM		038 04 4		066 65 X		094 25 CLR	
011 00 0		039 45 y^x		067 44 SUM		095 43 RCL	
012 05 5		040 43 RCL		068 01 1		096 00 0	
013 43 RCL		041 00 0		069 00 0		097 01 1	
014 00 0		042 03 3		070 43 RCL		098 56 *rtn	
015 04 4		043 65 X		071 00 0		099 46 *LBL	
016 20 *1/x		044 43 RCL		072 04 4		100 12 B	
017 65 X		045 00 0		073 95 =		101 90 *if zro	
018 43 RCL		046 02 2		074 44 SUM		102 87 *1'	
019 00 0		047 95 =		075 01 1		103 42 STO	
020 02 2		048 44 SUM		076 01 1		104 00 0	
021 95 =		049 00 0		077 43 RCL		105 02 2	
022 44 SUM		050 08 8		078 00 0		106 56 *rtn	
023 00 0		051 43 RCL		079 02 2		107 46 *LBL	
024 07 7		052 00 0		080 44 SUM		108 15 E	
025 43 RCL		053 04 4		081 00 0		109 25 CLR	
026 00 0		054 40 * x^2		082 01 1		110 47 *CMs	
027 04 4		055 65 X		083 43 RCL		111 01 1	

*Denotes 2nd function key

REGISTERS

00	05 Σf_x	10 Σfx^3	15
01 n	06 Πx^f	11 Σfx^4	16
02 f	07 $\Sigma f/x$	12 $\Sigma fx/n$	17
03 t	08 Σfx^t	13	18
04 last x	09 Σfx^2	14	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 42 STO		140 11 A		168 46 *LBL		196 47 *1'	
113 00 0		141 01 1		169 18 *C'		197 20 *1/x	
114 02 2		142 94 +/-		170 43 RCL		198 56 *rtn	
115 42 STO		143 22 INV		171 00 0		199 00	
116 00 0		144 49 *PROD		172 01 1		200 00	
117 06 6		145 00 0		173 55 ÷		201 00	
118 46 *LBL		146 02 2		174 43 RCL		202 00	
119 13 C		147 43 RCL		175 00 0		203 00	
120 90 *if zro		148 00 0		176 07 7		204 00	
121 87 *1'		149 01 1		177 95 =		205 00	
122 42 STO		150 56 *rtn		178 56 *rtn		206 00	
123 00 0		151 46 *LBL		179 46 *LBL		207 00	
124 03 3		152 16 *A'		180 19 *D'		208 00	
125 56 *rtn		153 43 RCL		181 43 RCL		209 00	
126 46 *LBL		154 01 1		182 00 0		210 00	
127 14 D		155 02 2		183 08 8		211 00	
128 42 STO		156 56 *rtn		184 55 ÷		212 00	
129 00 0		157 46 *LBL		185 43 RCL		213 00	
130 04 4		158 17 *B'		186 00 0		214 00	
131 01 1		159 43 RCL		187 01 1		215 00	
132 94 +/-		160 00 0		188 95 =		216 00	
133 22 INV		161 06 6		189 35 $\sqrt[x]{y}$		217 00	
134 49 *PROD		162 35 $\sqrt[x]{y}$		190 43 RCL		218 00	
135 00 0		163 43 RCL		191 00 0		219 00	
136 02 2		164 00 0		192 03 3		220 00	
137 43 RCL		165 01 1		193 95 =		221 00	
138 00 0		166 95 =		194 56 *rtn		222 00	
139 04 4		167 56 *rtn		195 46 *LBL		223 00	

*Denotes 2nd function key

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 03 3		056 55 ÷		084 09 9	
001 11 A		029 65 X		057 43 RCL		085 55 ÷	
002 43 RCL		030 43 RCL		058 00 0		086 43 RCL	
003 01 1		031 01 1		059 01 1		087 00 0	
004 02 2		032 02 2		060 75 -		088 01 1	
005 40 *x ²		033 65 X		061 04 4		089 75 -	
006 94 +/-		034 43 RCL		062 65 X		090 03 3	
007 85 +		035 00 0		063 43 RCL		091 65 X	
008 53 (		036 09 9		064 01 1		092 43 RCL	
009 43 RCL		037 55 ÷		065 02 2		093 01 1	
010 00 0		038 43 RCL		066 65 X		094 02 2	
011 09 9		039 00 0		067 43 RCL		095 40 *x ²	
012 55 ÷		040 01 1		068 01 1		096 40 *x ²	
013 43 RCL		041 85 +		069 00 0		097 95 =	
014 00 0		042 43 RCL		070 55 ÷		098 56 *rtn	
015 01 1		043 01 1		071 43 RCL		099 46 *LBL	
016 95 =		044 02 2		072 00 0		100 14 D	
017 56 *rtn		045 65 X		073 01 1		101 11 A	
018 46 *LBL		046 40 *x ²		074 85 +		102 40 *x ²	
019 12 B		047 65 X		075 06 6		103 42 STO	
020 43 RCL		048 02 2		076 65 X		104 01 1	
021 01 1		049 95 =		077 43 RCL		105 03 3	
022 00 0		050 56 *rtn		078 01 1		106 13 C	
023 55 ÷		051 46 *LBL		079 02 2		107 46 *LBL	
024 43 RCL		052 13 C		080 40 *x ²		108 87 *1'	
025 00 0		053 43 RCL		081 65 X		109 55 ÷	
026 01 1		054 01 1		082 43 RCL		110 43 RCL	
027 75 -		055 01 1		083 00 0		111 01 1	

*Denotes 2nd function key

REGISTERS

00	05 Σf_x	10 Σfx^3	15
01 n	06 Πx^f	11 Σfx^4	16
02 f	07 $\Sigma f/x$	12 $\Sigma fx/n$	17
03 t	08 Σfx^t	13 Used	18
04 last x	09 Σfx^2	14	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 03 3		140 35 $\sqrt[y]{x}$		168 43 RCL		196 00	
113 95 =		141 43 RCL		169 00 0		197 00	
114 56 *rtn		142 00 0		170 03 3		198 00	
115 46 *LBL		143 01 1		171 95 =		199 00	
116 15 E		144 95 =		172 56 *rtn		200 00	
117 11 A		145 56 *rtn		173 00		201 00	
118 65 X		146 46 *LBL		174 00		202 00	
119 40 *x ²		147 18 *C'		175 00		203 00	
120 95 =		148 43 RCL		176 00		204 00	
121 30 * $\sqrt{x}$		149 00 0		177 00		205 00	
122 95 =		150 01 1		178 00		206 00	
123 42 STO		151 55 ÷		179 00		207 00	
124 01 1		152 43 RCL		180 00		208 00	
125 03 3		153 00 0		181 00		209 00	
126 12 B		154 07 7		182 00		210 00	
127 41 GTO		155 95 =		183 00		211 00	
128 87 *1'		156 56 *rtn		184 00		212 00	
129 46 *LBL		157 46 *LBL		185 00		213 00	
130 16 *A'		158 19 *D'		186 00		214 00	
131 43 RCL		159 43 RCL		187 00		215 00	
132 01 1		160 00 0		188 00		216 00	
133 02 2		161 08 8		189 00		217 00	
134 56 *rtn		162 55 ÷		190 00		218 00	
135 46 *LBL		163 43 RCL		191 00		219 00	
136 17 *B'		164 00 0		192 00		220 00	
137 43 RCL		165 01 1		193 00		221 00	
138 00 0		166 95 =		194 00		222 00	
139 06 6		167 35 $\sqrt[y]{x}$		195 00		223 00	

*Denotes 2nd function key

RANDOM NUMBER GENERATOR

This program generates uniformly distributed random numbers ($0 \leq U_i \leq 1$) by use of the following formula:

$$U_{i+1} = 7^9 U_i (\text{Mod } 10^{10})$$

Where: $U_0 = 1$

Normally distributed random numbers are also generated, using the direct method:

$$A_i = (-2 \ln U_i)^{1/2} \cos(2\pi U_{i+1})$$

$$A_{i+1} = (-2 \ln U_i)^{1/2} \sin(2\pi U_{i+1})$$

Where: U_i and U_{i+1} are generated from the above method.

The final result is:

$$Y_i = \sigma A_i + m$$

which yields normally distributed random numbers with mean m and standard deviation σ . The user may input the standard deviation, mean, and U_i , or the default values are: $U_i = 0.55$, $\sigma = 1$, and $m = 0$.

- NOTES:
1. For normal distribution, the calculator must be in radian mode.
 2. The random numbers return as fixed point 5.
 3. The initial seed is 1.3597878×10^{10} , and is entered when **[A]** is pressed.
 4. The **[E]** and **2nd [E]** are of use only with the printer. **[E]** initiates continuous printing of U_i , and **2nd [E]** continuous printing of Y_i . Printing is stopped by pressing **[HLT]** and then **2nd rset**.

Example: To generate uniformly distributed random numbers the procedure is:

Enter	Press	Display	Comment
	[A]	0.00000	Initialize
	[B]	0.48405	U_1
	[B]	0.46815	U_2

Each pressing of **[B]** will display a new U_i . With a printer, pressing **[E]** once instead of **[B]** will produce a list of U_i which is stopped by pressing **[HLT]** and then **2nd rset**.

To generate normally distributed random numbers the procedure is:

Enter	Press	Display	Comment
	[A]	0.00000	Initialize
2	[C]	2.00000	mean
1	2nd [C]	1.00000	σ
	[D]	0.91202	Y_1
	[D]	2.10940	Y_2

Each pressing of **D** will display a new Y_i . With a printer, pressing **2nd** **E'** once instead of **D** will produce a list of Y_i which is stopped by pressing **HLT** and then **2nd** **rset**. If the mean and σ are not entered, the default values are $m = 0$ and $\sigma = 1$.

References: *Theory and Problems of Numerical Analysis*, Schaum's Outline Series, McGraw-Hill Book Company. *Handbook of Mathematical Functions*, U.S. Department of Commerce, National Bureau of Standards, 1964.

 TEXAS INSTRUMENTS				
ST1-04				
▶B◀ RANDOM NUMBER GENERATOR				
▶A◀ RANDOM NUMBER GENERATOR				
ST1-04				
		σ		list Y_i
INIT	U_i	mean	Y_i	list U_i

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Slide D/R switch					
	to R					
3	Initialize		A			0.
4	Compute U_i		B			U_i
	Each push produces					
	new U_i					
5	Enter mean	mean	C			mean
6	Enter σ	σ	2nd	C'		σ
7	Compute Y_i		D			Y_i
	Each push produces					
	new Y_i					
8	Printer list of U_i		E			
9	Printer list of Y_i		2nd	E'		
10	Stop step 8 or 9		HLT	2nd	rset	

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 01 1		056 00 0		084 95 =	
001 11 A		029 42 STO		057 09 9		085 22 INV	
002 01 1		030 00 0		058 95 =		086 52 EE	
003 93 •		031 04 4		059 22 INV		087 42 STO	
004 03 3		032 00 0		060 52 EE		088 00 0	
005 05 5		033 42 STO		061 75 −		089 00 0	
006 09 9		034 00 0		062 93 •		090 55 ÷	
007 07 7		035 05 5		063 05 5		091 01 1	
008 08 8		036 56 *rtn		064 57 *fix		092 00 0	
009 07 7		037 46 *LBL		065 00 0		093 52 EE	
010 08 8		038 12 B		066 95 =		094 00 0	
011 52 EE		039 24 CE		067 52 EE		095 09 9	
012 01 1		040 07 7		068 22 INV		096 22 INV	
013 00 0		041 45 y^x		069 52 EE		097 52 EE	
014 22 INV		042 09 9		070 57 *fix		098 95 =	
015 52 EE		043 95 =		071 05 5		099 42 STO	
016 42 STO		044 65 X		072 65 X		100 00 0	
017 00 0		045 43 RCL		073 01 1		101 08 8	
018 00 0		046 00 0		074 00 0		102 56 *rtn	
019 22 INV		047 00 0		075 52 EE		103 46 *LBL	
020 50 *st flg		048 95 =		076 00 0		104 13 C	
021 01 1		049 42 STO		077 09 9		105 42 STO	
022 93 •		050 00 0		078 95 =		106 00 0	
023 05 5		051 00 0		079 94 +/−		107 05 5	
024 05 5		052 55 ÷		080 85 +		108 56 *rtn	
025 42 STO		053 01 1		081 43 RCL		109 46 *LBL	
026 00 0		054 00 0		082 00 0		110 18 *C'	
027 06 6		055 52 EE		083 00 0		111 42 STO	

*Denotes 2nd function key

REGISTERS

00 Used	05 mean	10 Used	15
01 Used	06 Used	11	16
02	07 Used	12	17
03	08 Used	13	18
04 σ	09	14	19

FLAGS

0	1 Used	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 00 0		140 42 STO		168 43 RCL		196 00 0	
113 04 4		141 01 1		169 00 0		197 01 1	
114 93 •		142 00 0		170 04 4		198 16 *A'	
115 05 5		143 33 cos		171 85 +		199 56 *rtn	
116 05 5		144 42 STO		172 43 RCL		200 46 *LBL	
117 42 STO		145 00 0		173 00 0		201 15 E	
118 00 0		146 07 7		174 05 5		202 12 B	
119 06 6		147 43 RCL		175 95 =		203 98 *prt	
120 43 RCL		148 00 0		176 56 *rtn		204 41 GTO	
121 00 0		149 06 6		177 46 *LBL		205 15 E	
122 04 4		150 23 ln x		178 68 *8'		206 46 *LBL	
123 56 *rtn		151 65 X		179 22 INV		207 10 *E'	
124 46 *LBL		152 02 2		180 50 *st flg		208 14 D	
125 14 D		153 94 +/-		181 01 1		209 98 *prt	
126 60 *if flg		154 95 =		182 43 RCL		210 41 GTO	
127 01 1		155 30 $\sqrt{x}$		183 00 0		211 10 *E'	
128 68 *8'		156 42 STO		184 08 8		212 00	
129 50 *st flg		157 00 0		185 42 STO		213 00	
130 01 1		158 01 1		186 00 0		214 00	
131 12 B		159 16 *A'		187 06 6		215 00	
132 59 * π		160 56 *rtn		188 43 RCL		216 00	
133 65 X		161 46 *LBL		189 01 1		217 00	
134 43 RCL		162 16 *A'		190 00 0		218 00	
135 00 0		163 65 X		191 32 sin		219 00	
136 08 8		164 43 RCL		192 42 STO		220 00	
137 65 X		165 00 0		193 00 0		221 00	
138 02 2		166 07 7		194 07 7		222 00	
139 95 =		167 65 X		195 43 RCL		223 00	

*Denotes 2nd function key

ONE-WAY ANALYSIS OF VARIANCE (ANOVA)

One way analysis of variance is a technique for testing the differences between the population means of k treatment groups, where each group i ($i = 1, 2, \dots, k$) consists of n_i observations x_{ij} ($j = 1, 2, \dots, n_i$). The different groups need not have the same number of observations.

Formulas used:

$$\text{Sum of observations in group } i = \sum_{j=1}^{n_i} x_{ij}$$

$$\text{Total Sum of Squares} = SS = \sum_{i=1}^k \sum_{j=1}^{n_i} x_{ij}^2 - \frac{\left(\sum_{i=1}^k \sum_{j=1}^{n_i} x_{ij} \right)^2}{\sum_{i=1}^k n_i}$$

$$\text{Treatment Sum of Squares} = TSS = \sum_{i=1}^k \frac{\left(\sum_{j=1}^{n_i} x_{ij} \right)^2}{n_i} - \frac{\left(\sum_{i=1}^k \sum_{j=1}^{n_i} x_{ij} \right)^2}{\sum_{i=1}^k n_i}$$

$$\text{Error Sum of Squares} = ESS = SS - TSS$$

The value of the F statistic is:

$$F = \frac{DF_2 \times TSS}{DF_1 \times ESS}$$

Where: $DF_1 = \text{Treatment degrees of freedom} = k - 1$

$$DF_2 = \text{Error degrees of freedom} = \sum_{i=1}^k n_i - k$$

Example:

$i \backslash j$	1	2	3	4	5	6	7	$\bar{x}_{ij}$	σ_{ij}^2
1	15	25	20	12	22	18		18.66666667	18.55555556
2	30	45	25	46	19	33	37	33.57142857	85.10204082
3	5	19	14	16	7	3	21	12.14285714	43.55102041

$$F = 14.11952$$

$$DF_1 = 2$$

$$DF_2 = 17$$

$$SS = 2692.8$$

$$TSS = 1680.895238$$

$$ESS = 1011.904762$$

 TEXAS INSTRUMENTS				
ST1-05		ONE-WAY ANAL OF VARIANCE		
ST1-05		ONE-WAY ANAL OF VARIANCE		
	del x	σ^2	DF₂	
INIT	x	mean	DF₁	F

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS		DISPLAY
1	Enter Program (A and B)				
2	Initialize		A		0.
3	Enter x_{ij} for				
	$i = 1, j = 1, 2, \dots, n_i$	x_{ij}	B		j
4	Delete data if desired				
	(must be done before				
	step 5)	x_{ij}	2nd	B'	-1
5	Calculate $\bar{x}_i, \sigma_i^2$		C		$\bar{x}_i$
	(Step 5 must be				
	performed for each i)				
6	Display σ_i^2		2nd	C'	σ_i^2
7	Repeat steps 3-6				
	for $i = 2, \dots, k$				
8	Calculate F, DF ₁ , DF ₂		E		F
9	Display Treatment DF		D		DF ₁
10	Display Error DF		2nd	D'	DF ₂

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 56 *rtn		028 00 0		056 44 SUM		084 00 0	
001 46 *LBL		029 03 3		057 00 0		085 01 1	
002 11 A		030 40 *x ²		058 05 5		086 95 =	
003 25 CLR		031 94 +/—		059 55 ÷		087 42 STO	
004 47 *CMs		032 44 SUM		060 43 RCL		088 01 1	
005 86 *rset		033 00 0		061 00 0		089 09 9	
006 46 *LBL		034 04 4		062 01 1		090 43 RCL	
007 12 B		035 01 1		063 95 =		091 00 0	
008 44 SUM		036 94 +/—		064 42 STO		092 04 4	
009 00 0		037 44 SUM		065 01 1		093 44 SUM	
010 03 3		038 00 0		066 08 8		094 00 0	
011 40 *x ²		039 01 1		067 40 *x ²		095 06 6	
012 44 SUM		040 56 *rtn		068 65 X		096 00 0	
013 00 0		041 46 *LBL		069 43 RCL		097 42 STO	
014 04 4		042 13 C		070 00 0		098 00 0	
015 01 1		043 01 1		071 01 1		099 01 1	
016 44 SUM		044 44 SUM		072 95 =		100 42 STO	
017 00 0		045 00 0		073 44 SUM		101 00 0	
018 01 1		046 00 0		074 01 1		102 03 3	
019 43 RCL		047 43 RCL		075 07 7		103 42 STO	
020 00 0		048 00 0		076 94 +/—		104 00 0	
021 01 1		049 01 1		077 85 +		105 04 4	
022 56 *rtn		050 44 SUM		078 43 RCL		106 43 RCL	
023 46 *LBL		051 00 0		079 00 0		107 01 1	
024 17 *B'		052 02 2		080 04 4		108 08 8	
025 95 =		053 43 RCL		081 95 =		109 56 *rtn	
026 94 +/—		054 00 0		082 55 ÷		110 46 *LBL	
027 44 SUM		055 03 3		083 43 RCL		111 15 E	

*Denotes 2nd function key

REGISTERS

00 i count	05 $\sum \sum x_{ij}$	10 TSS	15 Error MS
01 j count	06 $\sum \sum (x_{ij})^2$	11 ESS	16 F
02 $\sum n_i$	07 Used	12 DF ₁	17 $\sum (\sum x_{ij})^2 / n_i$
03 $\sum x_{ij}$	08	13 Treat MS	18 m_j
04 $\sum (x_{ij})^2$	09 SS	14 DF ₂	19 σ_j^2

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 43 RCL		140 95 =		168 02 2		196 65 X	
113 00 0		141 42 STO		169 95 =		197 43 RCL	
114 05 5		142 01 1		170 42 STO		198 01 1	
115 40 *x ²		143 00 0		171 01 1		199 03 3	
116 55 ÷		144 94 +/—		172 03 3		200 95 =	
117 43 RCL		145 85 +		173 43 RCL		201 42 STO	
118 00 0		146 43 RCL		174 00 0		202 01 1	
119 02 2		147 00 0		175 02 2		203 06 6	
120 95 =		148 09 9		176 75 —		204 56 *rtn	
121 94 +/—		149 95 =		177 43 RCL		205 46 *LBL	
122 42 STO		150 42 STO		178 00 0		206 14 D	
123 00 0		151 01 1		179 00 0		207 43 RCL	
124 07 7		152 01 1		180 95 =		208 01 1	
125 85 +		153 43 RCL		181 42 STO		209 02 2	
126 43 RCL		154 00 0		182 01 1		210 56 *rtn	
127 00 0		155 00 0		183 04 4		211 46 *LBL	
128 06 6		156 75 —		184 43 RCL		212 19 *D'	
129 95 =		157 01 1		185 01 1		213 43 RCL	
130 42 STO		158 95 =		186 01 1		214 01 1	
131 00 0		159 42 STO		187 55 ÷		215 04 4	
132 09 9		160 01 1		188 43 RCL		216 56 *rtn	
133 43 RCL		161 02 2		189 01 1		217 46 *LBL	
134 00 0		162 43 RCL		190 04 4		218 18 *C'	
135 07 7		163 01 1		191 95 =		219 43 RCL	
136 85 +		164 00 0		192 42 STO		220 01 1	
137 43 RCL		165 55 ÷		193 01 1		221 09 9	
138 01 1		166 43 RCL		194 05 5		222 56 *rtn	
139 07 7		167 01 1		195 20 *1/x		223 00	

*Denotes 2nd function key

t STATISTIC EVALUATION (Paired Observations)

This program evaluates the t statistic

$$t = \frac{\bar{\Delta} \sqrt{n}}{S_{\Delta}}$$

with $n - 1$ degrees of freedom, to test the difference between the means (unknown) of two normally distributed populations, using paired values of data from the two populations.

Given the set of n pairs of x_i, y_i , let

$$\Delta_i = x_i - y_i$$

$$\bar{\Delta} = \frac{1}{n} \sum_{i=1}^n \Delta_i$$

$$S_{\Delta} = \left(\frac{\sum_{i=1}^n \Delta_i^2 - \frac{1}{n} \left(\sum_{i=1}^n \Delta_i \right)^2}{n - 1} \right)^{1/2}$$

Example:

x_i	6	4	7	4	3
y_i	2	3	5	4	3

$$t = 1.870828693$$

$$DF = 4.$$

$$\bar{\Delta} = 1.4$$

$$S_{\Delta} = 1.673320053$$

 TEXAS INSTRUMENTS				
90-11S		B t-STAT EVAL (PAIRED)		
A t-STAT EVAL (PAIRED)			ST1-06	
del x	del y	$\bar{\Delta}$	S_{Δ}	
x_t	y_i	t	DF	INIT

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Initialize		E			0.
3	Enter data	x_i	A			x_i
		y_i	B			i
4	To delete data					
	enter x	x	2nd	A'		x
	enter y	y	2nd	B'		N_y
5	Compute t		C			t
6	Compute DF		D			DF
7	Compute $\bar{\Delta}$		2nd	C'		$\bar{\Delta}$
8	Compute S_{Δ}		2nd	D'		S_{Δ}

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 56 *rtn		028 95 =		056 43 RCL		084 95 =	
001 46 *LBL		029 42 STO		057 00 0		085 55 ÷	
002 11 A		030 00 0		058 03 3		086 53 (	
003 42 STO		031 03 3		059 56 *rtn		087 43 RCL	
004 00 0		032 56 *rtn		060 46 *LBL		088 00 0	
005 01 1		033 46 *LBL		061 13 C		089 03 3	
006 56 *rtn		034 17 *B'		062 43 RCL		090 75 -	
007 46 *LBL		035 95 =		063 00 0		091 01 1	
008 12 B		036 94 +/-		064 02 2		092 95 =	
009 95 =		037 85 +		065 55 ÷		093 30 $\sqrt{x}$	
010 94 +/-		038 43 RCL		066 43 RCL		094 42 STO	
011 85 +		039 00 0		067 00 0		095 00 0	
012 43 RCL		040 01 1		068 03 3		096 05 5	
013 00 0		041 95 =		069 95 =		097 55 ÷	
014 01 1		042 94 +/-		070 42 STO		098 43 RCL	
015 95 =		043 44 SUM		071 00 0		099 00 0	
016 44 SUM		044 00 0		072 04 4		100 03 3	
017 00 0		045 02 2		073 40 x^2		101 30 $\sqrt{x}$	
018 02 2		046 40 x^2		074 65 X		102 95 =	
019 40 x^2		047 94 +/-		075 43 RCL		103 42 STO	
020 44 SUM		048 44 SUM		076 00 0		104 00 0	
021 00 0		049 00 0		077 03 3		105 06 6	
022 08 8		050 08 8		078 95 =		106 20 $1/x$	
023 43 RCL		051 01 1		079 94 +/-		107 65 X	
024 00 0		052 94 +/-		080 85 +		108 43 RCL	
025 03 3		053 44 SUM		081 43 RCL		109 00 0	
026 85 +		054 00 0		082 00 0		110 04 4	
027 01 1		055 03 3		083 08 8		111 95 =	

*Denotes 2nd function key

REGISTERS

00	05 s_{Δ}	10	15
01 x_i	06 $s_{\Delta}/\sqrt{n}$	11	16
02 $\Sigma \Delta_i$	07 t	12	17
03 Σn_i	08 $\Sigma \Delta_i^2$	13	18
04 $\bar{\Delta}$	09 y_i	14	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 42 STO		140 15 E		168 00		196 00	
113 00 0		141 25 CLR		169 00		197 00	
114 07 7		142 47 *CMs		170 00		198 00	
115 56 *rtn		143 86 *rset		171 00		199 00	
116 46 *LBL		144 00		172 00		200 00	
117 14 D		145 00		173 00		201 00	
118 43 RCL		146 00		174 00		202 00	
119 00 0		147 00		175 00		203 00	
120 03 3		148 00		176 00		204 00	
121 75 —		149 00		177 00		205 00	
122 01 1		150 00		178 00		206 00	
123 95 =		151 00		179 00		207 00	
124 56 *rtn		152 00		180 00		208 00	
125 46 *LBL		153 00		181 00		209 00	
126 18 *C'		154 00		182 00		210 00	
127 43 RCL		155 00		183 00		211 00	
128 00 0		156 00		184 00		212 00	
129 04 4		157 00		185 00		213 00	
130 95 =		158 00		186 00		214 00	
131 56 *rtn		159 00		187 00		215 00	
132 46 *LBL		160 00		188 00		216 00	
133 19 *D'		161 00		189 00		217 00	
134 43 RCL		162 00		190 00		218 00	
135 00 0		163 00		191 00		219 00	
136 05 5		164 00		192 00		220 00	
137 95 =		165 00		193 00		221 00	
138 56 *rtn		166 00		194 00		222 00	
139 46 *LBL		167 00		195 00		223 00	

*Denotes 2nd function key

t STATISTIC EVALUATION (TWO SAMPLE TEST)

This program evaluates the t statistic

$$t = \frac{\bar{x} - \bar{y} - \Delta}{\left(\frac{1}{n_x} + \frac{1}{n_y}\right)^{1/2} \left(\frac{\sum x_i^2 - n_x \bar{x}^2 + \sum y_j^2 - n_y \bar{y}^2}{n_x + n_y - 2}\right)^{1/2}}$$

with $n_x + n_y - 2$ degrees of freedom, to test the significance of the difference (Δ) between the means (unknown) of two independent random samples from two normally distributed populations having the same unknown variance.

Given the sample:

$$x_i = [x_1, x_2, \dots, x_{n_x}]$$

$$y_j = [y_1, y_2, \dots, y_{n_y}]$$

then

$$\bar{x} = \frac{1}{n_x} \sum_{i=1}^{n_x} x_i$$

$$\bar{y} = \frac{1}{n_y} \sum_{j=1}^{n_y} y_j$$

Example: $x_i : 71, 82, 105, 110, 124, 111, 126, 129$

$y_j : 57, 75, 86, 93, 98, 102, 115, 117, 121, 130$

For $\Delta = 0$, $t = .7562582916$
DF = 16.

 TEXAS INSTRUMENTS				
ST1-07 ←A t-STAT EVAL (TWO SAMPLE) B t-STAT EVAL (TWO SAMPLE)→				
←A t-STAT EVAL (TWO SAMPLE) ST1-07				
del x	del y			
x	y	Δ	DF	INIT

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Initialize		E			0.
3	Enter sample 1	x_i	A			i
	Repeat for all i					
4	Enter sample 2	y_j	B			j
	Repeat for all j					
5	To delete data					
	Enter x	x	2nd	A'		-1
	Enter y	y	2nd	B'		-1
6	Compute t	Δ	C			t
7	Compute DF		D			DF
	For other values of Δ ,					
	repeat step 6					

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 56 *rtn		028 44 SUM		056 00 0		084 00 0	
001 46 *LBL		029 00 0		057 06 6		085 08 8	
002 11 A		030 06 6		058 95 =		086 40 *x ²	
003 44 SUM		031 43 RCL		059 42 STO		087 85 +	
004 00 0		032 00 0		060 00 0		088 53 (	
005 01 1		033 06 6		061 09 9		089 43 RCL	
006 40 *x ²		034 56 *rtn		062 43 RCL		090 00 0	
007 44 SUM		035 46 *LBL		063 00 0		091 05 5	
008 00 0		036 13 C		064 03 3		092 75 -	
009 02 2		037 42 STO		065 85 +		093 43 RCL	
010 01 1		038 00 0		066 43 RCL		094 00 0	
011 44 SUM		039 07 7		067 00 0		095 06 6	
012 00 0		040 43 RCL		068 06 6		096 65 ×	
013 03 3		041 00 0		069 75 -		097 43 RCL	
014 43 RCL		042 01 1		070 02 2		098 00 0	
015 00 0		043 55 ÷		071 95 =		099 09 9	
016 03 3		044 43 RCL		072 42 STO		100 40 *x ²	
017 56 *rtn		045 00 0		073 01 1		101 95 =	
018 46 *LBL		046 03 3		074 00 0		102 55 ÷	
019 12 B		047 95 =		075 43 RCL		103 43 RCL	
020 44 SUM		048 42 STO		076 00 0		104 01 1	
021 00 0		049 00 0		077 02 2		105 00 0	
022 04 4		050 08 8		078 75 -		106 95 =	
023 40 *x ²		051 43 RCL		079 43 RCL		107 30 *√x	
024 44 SUM		052 00 0		080 00 0		108 42 STO	
025 00 0		053 04 4		081 03 3		109 01 1	
026 05 5		054 55 ÷		082 65 ×		110 01 1	
027 01 1		055 43 RCL		083 43 RCL		111 43 RCL	

*Denotes 2nd function key

REGISTERS

00	05 $\sum y_j^2$	10 DF	15
01 $\sum x_i$	06 n_y	11 Used	16
02 $\sum x_i^2$	07 Δ	12	17
03 n_x	08 $\bar{x}$	13	18
04 $\sum y_j$	09 $\bar{y}$	14	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 00 0		140 07 7		168 17 *B'		196 00	
113 03 3		141 95 =		169 95 =		197 00	
114 20 *1/x		142 56 *rtn		170 94 +/-		198 00	
115 85 +		143 46 *LBL		171 44 SUM		199 00	
116 43 RCL		144 14 D		172 00 0		200 00	
117 00 0		145 43 RCL		173 04 4		201 00	
118 06 6		146 01 1		174 40 *x ²		202 00	
119 20 *1/x		147 00 0		175 94 +/-		203 00	
120 95 =		148 56 *rtn		176 44 SUM		204 00	
121 30 *√x		149 46 *LBL		177 00 0		205 00	
122 65 ×		150 16 *A'		178 05 5		206 00	
123 43 RCL		151 95 =		179 01 1		207 00	
124 01 1		152 94 +/-		180 94 +/-		208 00	
125 01 1		153 44 SUM		181 44 SUM		209 00	
126 95 ÷		154 00 0		182 00 0		210 00	
127 20 *1/x		155 01 1		183 06 6		211 00	
128 65 X		156 40 *x ²		184 56 *rtn		212 00	
129 53 (		157 94 +/-		185 46 *LBL		213 00	
130 43 RCL		158 44 SUM		186 15 E		214 00	
131 00 0		159 00 0		187 25 CLR		215 00	
132 08 8		160 02 2		188 47 *CMs		216 00	
133 75 -		161 01 1		189 86 *rset		217 00	
134 43 RCL		162 94 +/-		190 00		218 00	
135 00 0		163 44 SUM		191 00		219 00	
136 09 9		164 00 0		192 00		220 00	
137 75 -		165 03 3		193 00		221 00	
138 43 RCL		166 56 *rtn		194 00		222 00	
139 00 0		167 46 *LBL		195 00		223 00	

*Denotes 2nd function key

LINEAR REGRESSION

The linear least-squares fit of input data points (x,y) is calculated using the following:

$$\text{Slope} = m = \frac{\frac{\sum x \sum y}{n} - \sum xy}{\frac{(\sum x)^2}{n} - \sum x^2}$$

$$\text{Intercept} = b = \frac{\sum y - m \sum x}{n}$$

The y' for entered x and x' for entered y are calculated as follows:

$$y' = mx + b$$

$$x' = (y - b)/m$$

The coefficient of determination is calculated as:

$$r^2 = m \left(\frac{\sum x \sum y}{n} - \sum xy \right) / \left(\sum y^2 - \frac{(\sum y)^2}{n} \right)$$

- NOTES: 1. The calculator must be initialized by pressing **2nd** **CMS** before each new set of data is entered.
2. The number of data points entered must be greater than 1 before any of the calculations are attempted.
3. This program may be used with the Basic Statistics program (ST1-01) to determine additional statistics. Data points entered on either program may be used for the other. Do not initialize if data from the other program is being used.

Example:

x	20.4	19.7	21.8	20.1	20.7
y	9.2	8.9	11.4	9.4	10.3

$$r^2 = .9256678121$$

$$m = 1.22906793$$

$$b = -15.40505529$$

$$\text{For } y = 12, x' = 22.29742931$$

$$\text{For } x = 22.3, y' = 12.00315956$$

 TEXAS INSTRUMENTS				
80-LIS		NOISSION		
←A← LINEAR REGRESSION				ST1-08
y → x'	x → y'		delete	
x	y	r²	slope	intcpt

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Initialize		2nd	CMs		
3	Enter data	x (YEAR)	A			x
	Repeat 3 for each x,y	y (DEPEND)	B			n
4	Delete data					
	a. Enter x (not necessary if deleting last pair entered)	x	A			x
	b. Enter y	y	2nd	D'		n-1
5	Calculate					
	a. r ²	coefficient	C			r ²
	b. slope		D			m
	c. intercept		E			b
	d. x'	y	2nd	A'		x'
	e. y' →	x	2nd	B'		y'

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 01 1		056 43 RCL		084 00 0	
001 19 *D'		029 94 +/—		057 00 0		085 01 1	
002 95 =		030 44 SUM		058 00 0		086 44 SUM	
003 94 +/—		031 00 0		059 56 *rtn		087 00 0	
004 42 STO		032 03 3		060 46 *LBL		088 03 3	
005 00 0		033 40 *x ²		061 12 B		089 40 *x ²	
006 02 2		034 94 +/—		062 42 STO		090 44 SUM	
007 44 SUM		035 44 SUM		063 00 0		091 00 0	
008 00 0		036 00 0		064 02 2		092 06 6	
009 04 4		037 06 6		065 44 SUM		093 01 1	
010 40 *x ²		038 01 1		066 00 0		094 41 GTO	
011 94 +/—		039 94 +/—		067 04 4		095 88 *2'	
012 44 SUM		040 46 *LBL		068 40 *x ²		096 46 *LBL	
013 00 0		041 88 *2'		069 44 SUM		097 14 D	
014 07 7		042 44 SUM		070 00 0		098 43 RCL	
015 43 RCL		043 00 0		071 07 7		099 00 0	
016 00 0		044 00 0		072 43 RCL		100 03 3	
017 02 2		045 43 RCL		073 00 0		101 55 ÷	
018 65 X		046 00 0		074 02 2		102 43 RCL	
019 43 RCL		047 00 0		075 65 X		103 00 0	
020 00 0		048 75 —		076 43 RCL		104 00 0	
021 01 1		049 01 1		077 00 0		105 65 X	
022 95 =		050 95 =		078 01 1		106 42 STO	
023 44 SUM		051 30 *√x		079 95 =		107 01 1	
024 00 0		052 42 STO		080 44 SUM		108 00 0	
025 05 5		053 00 0		081 00 0		109 43 RCL	
026 43 RCL		054 08 8		082 05 5		110 00 0	
027 00 0		055 25 CLR		083 43 RCL		111 04 4	

*Denotes 2nd function key

REGISTERS

00 n	05 Σxy	10 $\bar{x}$	15
01 x	06 Σx^2	11 m	16
02 y	07 Σy^2	12 Used	17
03 Σx	08 $\sqrt{n-1}$	13 Used	18
04 Σy	09	14	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 75 —		140 77 *4'		168 85 +		196 65 X	
113 43 RCL		141 42 STO		169 43 RCL		197 43 RCL	
114 00 0		142 01 1		170 01 1		198 01 1	
115 05 5		143 02 2		171 02 2		199 03 3	
116 95 =		144 46 *LBL		172 95 =		200 55 ÷	
117 94 +/-		145 15 E		173 55 ÷		201 53 (	
118 42 STO		146 14 D		174 46 *LBL		202 43 RCL	
119 01 1		147 65 X		175 87 *1'		203 00 0	
120 03 3		148 43 RCL		176 43 RCL		204 04 4	
121 55 ÷		149 00 0		177 01 1		205 40 *x ²	
122 53 (		150 03 3		178 01 1		206 55 ÷	
123 43 RCL		151 94 +/-		179 95 =		207 43 RCL	
124 00 0		152 85 +		180 56 *rtn		208 00 0	
125 06 6		153 43 RCL		181 46 *LBL		209 00 0	
126 75 —		154 00 0		182 17 *B'		210 94 +/-	
127 43 RCL		155 04 4		183 51 SBR		211 85 +	
128 00 0		156 95 =		184 77 *4'		212 43 RCL	
129 03 3		157 55 ÷		185 85 +		213 00 0	
130 65 X		158 43 RCL		186 53 (		214 07 7	
131 43 RCL		159 00 0		187 43 RCL		215 95 =	
132 01 1		160 00 0		188 01 1		216 56 *rtn	
133 00 0		161 95 =		189 02 2		217 46 *LBL	
134 95 =		162 56 *rtn		190 65 X		218 11 A	
135 42 STO		163 46 *LBL		191 41 GTO		219 42 STO	
136 01 1		164 16 *A'		192 87 *1'		220 00 0	
137 01 1		165 51 SBR		193 46 *LBL		221 01 1	
138 56 *rtn		166 77 *4'		194 13 C		222 56 *rtn	
139 46 *LBL		167 94 +/-		195 14 D		223 00	

*Denotes 2nd function key

POWER CURVE FIT

Given a set of data points:

$$\{x_i, y_i\}, i = 1, 2, \dots, n\}$$

Where: $x_i > 0$ and $y_i > 0$, this program will fit a power curve:

$$y = ax^b \quad (a > 0)$$

The problem may be interpreted as a linear regression problem by using the equation in the form:

$$\ln y = b \ln x + \ln a$$

The computed statistics are:

1. Regression coefficients

$$a = \exp \left[\frac{\sum \ln y_i}{n} - \frac{b \sum \ln x_i}{n} \right]$$

$$b = \frac{\sum (\ln x_i)(\ln y_i) - \frac{(\sum \ln x_i)(\sum \ln y_i)}{n}}{\sum (\ln x_i)^2 - \frac{(\sum \ln x_i)^2}{n}}$$

NOTE: n is a positive integer $\neq 1$.

2. Correlation coefficient

$$r^2 = \frac{\left[\sum (\ln x_i)(\ln y_i) - \frac{(\sum \ln x_i)(\sum \ln y_i)}{n} \right]^2}{\left[\sum (\ln x_i)^2 - \frac{(\sum \ln x_i)^2}{n} \right] \left[\sum (\ln y_i)^2 - \frac{(\sum \ln y_i)^2}{n} \right]}$$

3. Estimated value x' for given y

$$x' = \sqrt[b]{y/a}$$

4. Estimated value y' for given x

$$y' = ax^b$$

Example:

x_i	3	6	8	11	13.5	15	18.5	20
y_i	.8	1.12	1.3	1.53	1.95	2.4	3.0	3.7

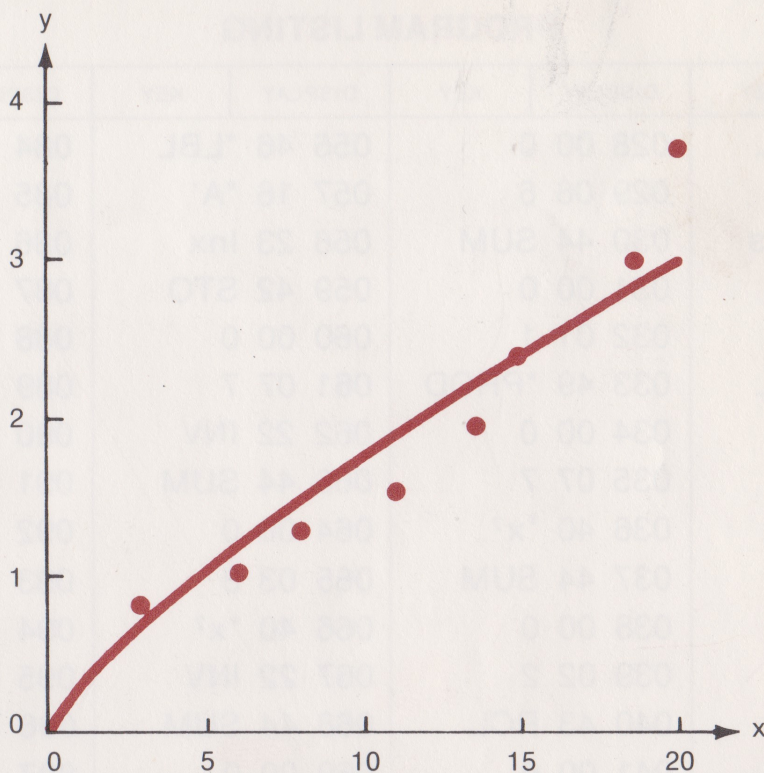
$$a = .2901902009$$

$$b = .7759169351$$

$$r^2 = 0.921727263$$

$$\text{for } x = 9, y' = 1.596230726$$

$$\text{for } y = 2.8, x' = 18.56904361$$



 TEXAS INSTRUMENTS				
60-TLS		POWER CURVE FIT		
POWER CURVE FIT				ST1-09
delete	$y \rightarrow x'$	$x \rightarrow y'$	b	
INIT	x_i	y_i	a	r^2

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS		DISPLAY
1	Enter Program (A and B)				
2	Initialize		A		0.
3	Enter data	x_i	B		x_i
	(repeat for all i)	y_i	C		n
4	Delete data				
	a. Enter x	x	B		x
	b. Enter y	y	2nd A'		n-1
5	Calculate regression		D		a
	coefficients		2nd D'		b
6	Calculate correlation		E		r^2
	coefficient				
7	Compute estimated				
	value for				
	x' given y	y	2nd B'		x'
	y' given x	x	2nd C'		y'

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 00 0		056 46 *LBL		084 00 0	
001 11 A		029 06 6		057 16 *A'		085 02 2	
002 47 *CMs		030 44 SUM		058 23 Inx		086 43 RCL	
003 25 CLR		031 00 0		059 42 STO		087 00 0	
004 56 *rtn		032 01 1		060 00 0		088 07 7	
005 46 *LBL		033 49 *PROD		061 07 7		089 22 INV	
006 12 B		034 00 0		062 22 INV		090 44 SUM	
007 23 Inx		035 07 7		063 44 SUM		091 00 0	
008 42 STO		036 40 *x ²		064 00 0		092 04 4	
009 00 0		037 44 SUM		065 03 3		093 01 1	
010 06 6		038 00 0		066 40 *x ²		094 94 +/-	
011 22 INV		039 02 2		067 22 INV		095 41 GTO	
012 23 Inx		040 43 RCL		068 44 SUM		096 87 *1'	
013 56 *rtn		041 00 0		069 00 0		097 46 *LBL	
014 46 *LBL		042 07 7		070 05 5		098 14 D	
015 13 C		043 44 SUM		071 43 RCL		099 43 RCL	
016 23 Inx		044 00 0		072 00 0		100 00 0	
017 42 STO		045 04 4		073 06 6		101 02 2	
018 00 0		046 01 1		074 22 INV		102 75 —	
019 07 7		047 46 *LBL		075 44 SUM		103 43 RCL	
020 44 SUM		048 87 *1'		076 00 0		104 00 0	
021 00 0		049 44 SUM		077 01 1		105 01 1	
022 03 3		050 00 0		078 49 *PROD		106 40 *x ²	
023 40 *x ²		051 00 0		079 00 0		107 55 ÷	
024 44 SUM		052 43 RCL		080 07 7		108 43 RCL	
025 00 0		053 00 0		081 40 *x ²		109 00 0	
026 05 5		054 00 0		082 22 INV		110 00 0	
027 43 RCL		055 56 *rtn		083 44 SUM		111 95 =	

*Denotes 2nd function key

REGISTERS

00 n	05 $\Sigma(\ln y)^2$	10 Used	15
01 $\Sigma \ln x$	06 $\ln x$	11 Used	16
02 $\Sigma(\ln x)^2$	07 $\ln y$	12 r^2	17
03 $\Sigma \ln y$	08 b	13	18
04 $\Sigma(\ln x)(\ln y)$	09 a	14	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 20 $\ast 1/x$		140 08 8		168 46 $\ast \text{LBL}$		196 01 1	
113 42 STO		141 94 $\div$		169 17 $\ast B'$		197 00 0	
114 01 1		142 65 X		170 55 $\div$		198 65 X	
115 00 0		143 43 RCL		171 43 RCL		199 53 (	
116 65 X		144 00 0		172 00 0		200 43 RCL	
117 53 (		145 01 1		173 09 9		201 00 0	
118 43 RCL		146 85 +		174 95 =		202 05 5	
119 00 0		147 43 RCL		175 35 $\sqrt[x]{y}$		203 75 -	
120 04 4		148 00 0		176 43 RCL		204 43 RCL	
121 75 -		149 03 3		177 00 0		205 00 0	
122 43 RCL		150 95 =		178 08 8		206 03 3	
123 00 0		151 55 $\div$		179 95 =		207 40 $\ast x^2$	
124 01 1		152 43 RCL		180 56 $\ast \text{rtn}$		208 55 $\div$	
125 65 X		153 00 0		181 46 $\ast \text{LBL}$		209 43 RCL	
126 43 RCL		154 00 0		182 18 $\ast C'$		210 00 0	
127 00 0		155 95 =		183 45 y^x		211 00 0	
128 03 3		156 22 INV		184 43 RCL		212 54)	
129 55 $\div$		157 23 $\ln x$		185 00 0		213 20 $\ast 1/x$	
130 43 RCL		158 42 STO		186 08 8		214 65 X	
131 00 0		159 00 0		187 65 X		215 43 RCL	
132 00 0		160 09 9		188 43 RCL		216 01 1	
133 54)		161 56 $\ast \text{rtn}$		189 00 0		217 01 1	
134 42 STO		162 46 $\ast \text{LBL}$		190 09 9		218 40 $\ast x^2$	
135 01 1		163 19 $\ast D'$		191 95 =		219 95 =	
136 01 1		164 43 RCL		192 56 $\ast \text{rtn}$		220 42 STO	
137 95 =		165 00 0		193 46 $\ast \text{LBL}$		221 01 1	
138 42 STO		166 08 8		194 15 E		222 02 2	
139 00 0		167 56 $\ast \text{rtn}$		195 43 RCL		223 56 $\ast \text{rtn}$	

*Denotes 2nd function key

EXPONENTIAL CURVE FIT

Given a set of data points:

$$\{(x_i, y_i), i = 1, 2, \dots, n\} \quad y_i > 0$$

This program finds the least-squares fit for an exponential function of the form:

$$y = ae^{bx} \quad (a > 0)$$

The problem is computed according to the linear equation

$$\ln y = \ln a + bx$$

Statistical outputs:

1. Coefficients a, b

$$a = \exp \left[\frac{\sum \ln y_i}{n} - b \frac{\sum x_i}{n} \right]$$

$$b = \frac{\sum x_i \ln y_i - \frac{\sum x_i \sum \ln y_i}{n}}{\sum x_i^2 - \frac{(\sum x_i)^2}{n}}$$

Note: n is positive integer $\neq 1$.

2. Correlation coefficient

$$r^2 = \frac{\left[\sum x_i \ln y_i - \frac{\sum x_i \sum \ln y_i}{n} \right]^2}{\left[\sum x_i^2 - \frac{(\sum x_i)^2}{n} \right] \left[\sum (\ln y_i)^2 - \frac{(\sum \ln y_i)^2}{n} \right]}$$

3. Estimated value for x' given y

$$x' = \frac{1}{b} \ln \left(\frac{y}{a} \right)$$

4. Estimated value for y' given x

$$y' = ae^{bx}$$

Example:

x_i	1.42	1.94	2.63	3.11	3.7	4.25
y_i	.63	.9	1.42	1.9	2.43	2.89

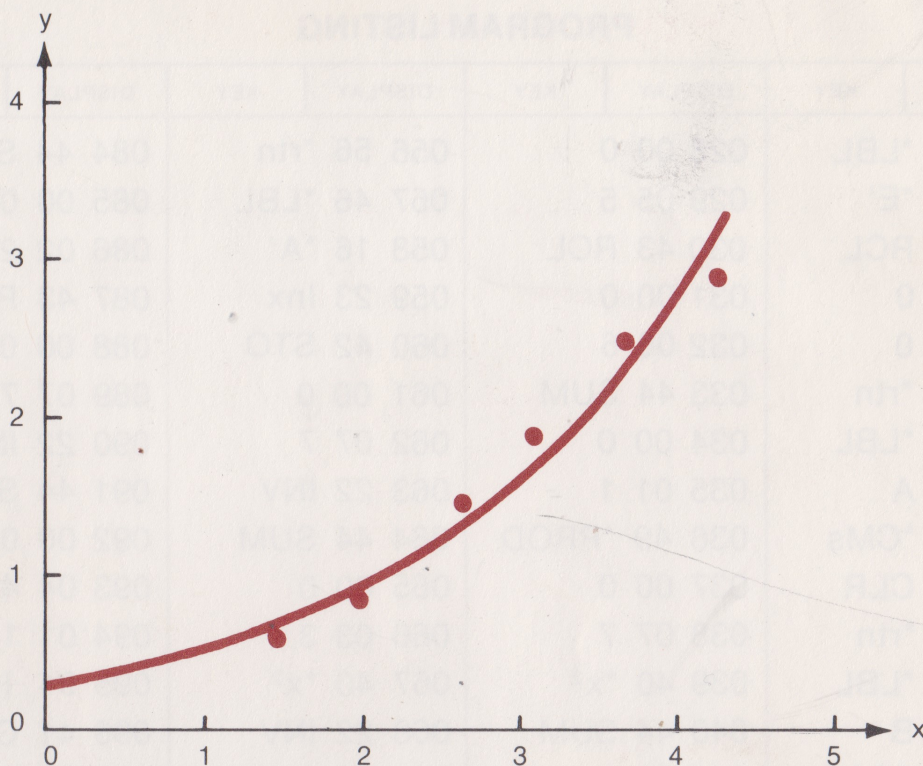
$$a = .3131935086$$

$$b = .5477927735$$

$$r^2 = .9810626986$$

$$\text{For } x = 1.6, \quad y' = .7524162355$$

$$\text{For } y = 2.2, \quad x' = 3.558629277$$



 TEXAS INSTRUMENTS				
ST1-10				
EXPONENTIAL CURVE FIT				
ST1-10				
delete	$y \rightarrow x'$	$x \rightarrow y'$	b	
INIT	x_i	y_i	a	r^2

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Initialize		A			0.
3	Enter data	x_i (XRS)	B			x_i
	(repeat for all i)	y_i (YDATA)	C			n
4	Delete data					
	a. Enter x	x	B			x
	b. Enter y	y	2nd A'			n-1
5	Calculate coefficients		D			a
			2nd D'			b
6	Calculate correlation coefficient		E			r^2
7	Compute estimated value for					
	x' given y	y	2nd B'			x'
	y' given x $\rightarrow$	x	2nd C'			y'

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 00 0		056 56 *rtn		084 44 SUM	
001 10 *E'		029 05 5		057 46 *LBL		085 00 0	
002 43 RCL		030 43 RCL		058 16 *A'		086 02 2	
003 00 0		031 00 0		059 23 Inx		087 43 RCL	
004 00 0		032 06 6		060 42 STO		088 00 0	
005 56 *rtn		033 44 SUM		061 00 0		089 07 7	
006 46 *LBL		034 00 0		062 07 7		090 22 INV	
007 11 A		035 01 1		063 22 INV		091 44 SUM	
008 47 *CMs		036 49 *PROD		064 44 SUM		092 00 0	
009 25 CLR		037 00 0		065 00 0		093 04 4	
010 56 *rtn		038 07 7		066 03 3		094 01 1	
011 46 *LBL		039 40 *x ²		067 40 *x ²		095 94 +/—	
012 12 B		040 44 SUM		068 22 INV		096 41 GTO	
013 42 STO		041 00 0		069 44 SUM		097 87 *1'	
014 00 0		042 02 2		070 00 0		098 46 *LBL	
015 06 6		043 43 RCL		071 05 5		099 14 D	
016 56 *rtn		044 00 0		072 43 RCL		100 43 RCL	
017 46 *LBL		045 07 7		073 00 0		101 00 0	
018 13 C		046 44 SUM		074 06 6		102 02 2	
019 23 Inx		047 00 0		075 22 INV		103 75 —	
020 42 STO		048 04 4		076 44 SUM		104 43 RCL	
021 00 0		049 01 1		077 00 0		105 00 0	
022 07 7		050 46 *LBL		078 01 1		106 01 1	
023 44 SUM		051 87 *1'		079 49 *PROD		107 40 *x ²	
024 00 0		052 44 SUM		080 00 0		108 55 ÷	
025 03 3		053 00 0		081 07 7		109 10 *E'	
026 40 *x ²		054 00 0		082 40 *x ²		110 95 =	
027 44 SUM		055 10 *E'		083 22 INV		111 20 *1/x	

*Denotes 2nd function key

REGISTERS

00 n	05 $\Sigma(\ln y)^2$	10 Used	15
01 Σx	06 x	11 Used	16
02 Σx^2	07 x lny	12 r ²	17
03 $\Sigma \ln y$	08 b	13	18
04 $\Sigma x \ln y$	09 a	14	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 42 STO		140 43 RCL		168 09 9		196 00 0	
113 01 1		141 00 0		169 95 =		197 65 X	
114 00 0		142 01 1		170 23 Inx		198 53 (	
115 65 X		143 85 +		171 55 ÷		199 43 RCL	
116 53 (		144 43 RCL		172 43 RCL		200 00 0	
117 43 RCL		145 00 0		173 00 0		201 05 5	
118 00 0		146 03 3		174 08 8		202 75 —	
119 04 4		147 95 =		175 95 =		203 43 RCL	
120 75 —		148 55 ÷		176 56 *rtn		204 00 0	
121 43 RCL		149 10 *E'		177 46 *LBL		205 03 3	
122 00 0		150 95 =		178 18 *C'		206 40 *x ²	
123 01 1		151 22 INV		179 65 X		207 55 ÷	
124 65 X		152 23 Inx		180 43 RCL		208 10 *E'	
125 43 RCL		153 42 STO		181 00 0		209 54)	
126 00 0		154 00 0		182 08 8		210 20 *1/x	
127 03 3		155 09 9		183 95 =		211 65 X	
128 55 ÷		156 56 *rtn		184 22 INV		212 43 RCL	
129 10 *E'		157 46 *LBL		185 23 Inx		213 01 1	
130 54)		158 19 *D'		186 65 X		214 01 1	
131 42 STO		159 43 RCL		187 43 RCL		215 40 *x ²	
132 01 1		160 00 0		188 00 0		216 95 =	
133 01 1		161 08 8		189 09 9		217 42 STO	
134 95 =		162 56 *rtn		190 95 =		218 01 1	
135 42 STO		163 46 *LBL		191 56 *rtn		219 02 2	
136 00 0		164 17 *B'		192 46 *LBL		220 56 *rtn	
137 08 8		165 55 ÷		193 15 E		221 00	
138 94 +/-		166 43 RCL		194 43 RCL		222 00	
139 65 X		167 00 0		195 01 1		223 00	

*Denotes 2nd function key

LOGARITHMIC CURVE FIT

Given a set of data points:

$$\{(x_i, y_i), i = 1, 2, \dots, n\}$$

Where: $x_i > 0$, this program fits a logarithmic curve:

$$y = a + b \ln x$$

Statistical outputs:

1. Regression coefficients

$$a = \frac{\sum y_i - b \sum \ln x_i}{n}$$

$$b = \frac{\sum y_i \ln x_i - \frac{\sum \ln x_i \sum y_i}{n}}{\sum (\ln x_i)^2 - \frac{(\sum \ln x_i)^2}{n}}$$

2. Correlation coefficient

$$r^2 = \frac{\left[\sum y_i \ln x_i - \frac{\sum \ln x_i \sum y_i}{n} \right]^2}{\left[\sum (\ln x_i)^2 - \frac{(\sum \ln x_i)^2}{n} \right] \left[\sum y_i^2 - \frac{(\sum y_i)^2}{n} \right]}$$

3. Estimated value for x' given y

$$x' = \exp \left[\frac{y - a}{b} \right]$$

4. Estimated value for y' given x

$$y' = a + b \ln x$$

NOTE: n is positive integer $\neq 1$.

Example:

x_i	2	5	7	11	13	14
y_i	5.3	10.8	17.5	28.2	36.9	44.4

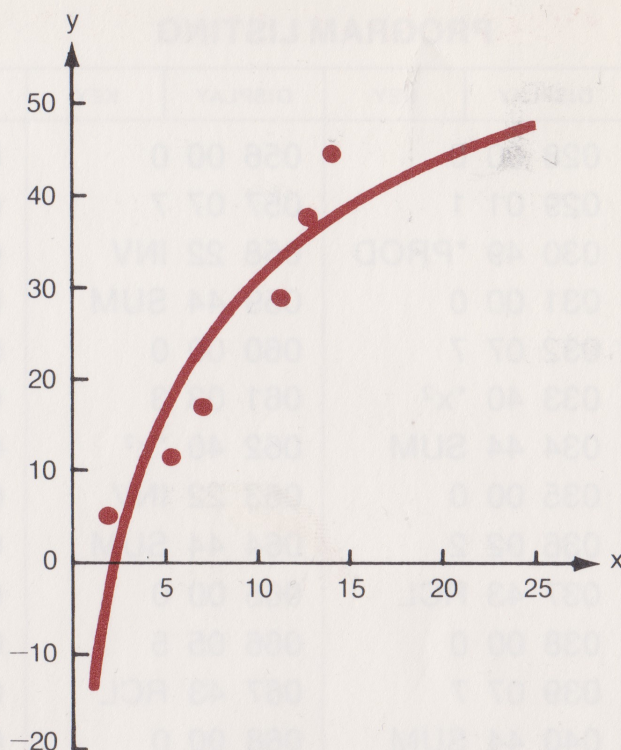
$$a = -13.49953513$$

$$b = 18.91052316$$

$$r^2 = .8418448418$$

$$\text{For } x = 21, \quad y' = 44.07397695$$

$$\text{For } y = 40, \quad x' = 16.93001448$$



 TEXAS INSTRUMENTS				
ST1-11 LOGARITHMIC CURVE FIT				
ST1-11 LOGARITHMIC CURVE FIT				
delete	$y \rightarrow x'$	$x \rightarrow y'$	b	
INIT	x_i	y_i	a	r^2

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Initialize		A			0.
3	Enter data	x_i	B			x_i
	(repeat for all i)	y_i	C			n
4	Delete data					
	a. Enter x	x	B			x
	b. Enter y	y	2nd A'			n-1
5	Calculate coefficients		D			a
			2nd D'			b
6	Calculate correlation coefficient		E			r^2
7	Compute estimated value for					
	x' given y	y	2nd B'			x'
	y' given x	x	2nd C'			y'

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 00 0		056 00 0		084 00 0	
001 11 A		029 01 1		057 07 7		085 07 7	
002 47 *CMs		030 49 *PROD		058 22 INV		086 22 INV	
003 25 CLR		031 00 0		059 44 SUM		087 44 SUM	
004 56 *rtn		032 07 7		060 00 0		088 00 0	
005 46 *LBL		033 40 *x ²		061 03 3		089 04 4	
006 12 B		034 44 SUM		062 40 *x ²		090 01 1	
007 42 STO		035 00 0		063 22 INV		091 94 +/—	
008 00 0		036 02 2		064 44 SUM		092 41 GTO	
009 06 6		037 43 RCL		065 00 0		093 87 *1'	
010 56 *rtn		038 00 0		066 05 5		094 46 *LBL	
011 46 *LBL		039 07 7		067 43 RCL		095 14 D	
012 13 C		040 44 SUM		068 00 0		096 43 RCL	
013 42 STO		041 00 0		069 06 6		097 00 0	
014 00 0		042 04 4		070 23 ln x		098 02 2	
015 07 7		043 01 1		071 22 INV		099 75 —	
016 44 SUM		044 46 *LBL		072 44 SUM		100 43 RCL	
017 00 0		045 87 *1'		073 00 0		101 00 0	
018 03 3		046 44 SUM		074 01 1		102 01 1	
019 40 *x ²		047 00 0		075 49 *PROD		103 40 *x ²	
020 44 SUM		048 00 0		076 00 0		104 55 ÷	
021 00 0		049 43 RCL		077 07 7		105 43 RCL	
022 05 5		050 00 0		078 40 *x ²		106 00 0	
023 43 RCL		051 00 0		079 22 INV		107 00 0	
024 00 0		052 56 *rtn		080 44 SUM		108 95 =	
025 06 6		053 46 *LBL		081 00 0		109 20 *1/x	
026 23 ln x		054 16 *A'		082 02 2		110 42 STO	
027 44 SUM		055 42 STO		083 43 RCL		111 01 1	

*Denotes 2nd function key

REGISTERS

00 n	05 Σy^2	10 Used	15
01 $\Sigma \ln x$	06 x	11 Used	16
02 $\Sigma (\ln x)^2$	07 y	12 r^2	17
03 Σy	08 b	13	18
04 $\Sigma y \ln x$	09 a	14	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 00 0		140 43 RCL		168 65 X		196 75 —	
113 65 X		141 00 0		169 53 (		197 43 RCL	
114 53 (		142 01 1		170 43 RCL		198 00 0	
115 43 RCL		143 85 +		171 00 0		199 09 9	
116 00 0		144 43 RCL		172 05 5		200 95 =	
117 04 4		145 00 0		173 75 —		201 55 ÷	
118 75 —		146 03 3		174 43 RCL		202 43 RCL	
119 43 RCL		147 95 =		175 00 0		203 00 0	
120 00 0		148 55 ÷		176 03 3		204 08 8	
121 01 1		149 43 RCL		177 40 *x ²		205 95 =	
122 65 X		150 00 0		178 55 ÷		206 22 INV	
123 43 RCL		151 00 0		179 43 RCL		207 23 Inx	
124 00 0		152 95 =		180 00 0		208 56 *rtn	
125 03 3		153 42 STO		181 00 0		209 46 *LBL	
126 55 ÷		154 00 0		182 54)		210 18 *C'	
127 43 RCL		155 09 9		183 20 *1/x		211 23 Inx	
128 00 0		156 56 *rtn		184 65 X		212 65 X	
129 00 0		157 46 *LBL		185 43 RCL		213 43 RCL	
130 54)		158 19 *D'		186 01 1		214 00 0	
131 42 STO		159 43 RCL		187 01 1		215 08 8	
132 01 1		160 00 0		188 40 *x ²		216 85 +	
133 01 1		161 08 8		189 95 =		217 43 RCL	
134 95 =		162 56 *rtn		190 42 STO		218 00 0	
135 42 STO		163 46 *LBL		191 01 1		219 09 9	
136 00 0		164 15 E		192 02 2		220 95 =	
137 08 8		165 43 RCL		193 56 *rtn		221 56 *rtn	
138 94 +/-		166 01 1		194 46 *LBL		222 00	
139 65 X		167 00 0		195 17 *B'		223 00	

*Denotes 2nd function key

MULTIPLE LINEAR REGRESSION

Using the least-squares method this program (2 cards) derives a linear equation of the form:

$$z = a_0 + a_1x + a_2y$$

for a given set of data points:

$$\{(x_i, y_i, z_i), i = 1, 2, \dots, n\}$$

According to the normal equations

$$\sum z_i = a_0n + a_1\sum x_i + a_2\sum y_i$$

$$\sum x_i z_i = a_0\sum x_i + a_1\sum x_i^2 + a_2\sum x_i y_i$$

$$\sum y_i z_i = a_0\sum y_i + a_1\sum x_i y_i + a_2\sum y_i^2$$

the regression coefficients a_0 , a_1 , a_2 may be computed.

$$a_2 = \frac{N_1 - N_2}{[n\sum x_i^2 - (\sum x_i)^2][n\sum y_i^2 - (\sum y_i)^2] - [n\sum x_i y_i - (\sum x_i)(\sum y_i)]^2}$$

Where: $N_1 = [n\sum x_i^2 - (\sum x_i)^2][n\sum y_i z_i - (\sum y_i)(\sum z_i)]$

$$N_2 = [n\sum x_i y_i - (\sum x_i)(\sum y_i)][n\sum x_i z_i - (\sum x_i)(\sum z_i)]$$

$$a_1 = \frac{[n\sum x_i z_i - (\sum x_i)(\sum z_i)] - a_2[n\sum x_i y_i - (\sum x_i)(\sum y_i)]}{n\sum x_i^2 - (\sum x_i)^2}$$

$$a_0 = \frac{\sum z_i - a_2\sum y_i - a_1\sum x_i}{n}$$

NOTE: n is positive integer $\neq 1$

Card 1 is used when entering data points. If an error is made while entering coordinates, the incorrect data may be deleted by entering x_i and y_i in the normal manner. Then, z_i should be entered in the display and **[D]** pressed to delete x , y , and z . When all data points have been entered, any sum may be recalled by pressing **[RCL]** and the corresponding data register number (refer to User Instructions).

Card 2 must be loaded before calculating the regression coefficients. After the coefficients are determined, the estimated value for $z_i(z')$ may be computed for a given x_i and y_i .

Reference: *Computer Methods for Science and Engineering*, Robert LaFara, Hayden Book Co., 1973

Example:

x_i	.75	2.2	1.3	2.6
y_i	1.1	1.88	1.24	2.9
z_i	1.5	3.1	4.4	5.85

1. Regression line:

$$z = .6462676006 + .4986757882x + 1.242837142y$$

2. Regression coefficients:

$$a_0 = .6462676006$$

$$a_1 = .4986757882$$

$$a_2 = 1.242837142$$

For: $x = 1, y = 2.5, z' = 4.252036243$

Registers:	R ₀₀	$n = 4$	R ₀₅	$\sum y_i^2 = 14.692$
	R ₀₁	$\sum x_i = 6.85$	R ₀₆	$\sum x_i y_i = 14.113$
	R ₀₂	$\sum y_i = 7.12$	R ₀₇	$\sum x_i z_i = 28.875$
	R ₀₃	$\sum z_i = 14.85$	R ₀₈	$\sum y_i z_i = 29.899$
	R ₀₄	$\sum x_i^2 = 13.8525$		

					TEXAS INSTRUMENTS				
ST1-12-1		B  M'TIPLE LIN REGRESSION(1)							
		 A  M'TIPLE LIN REGRESSION(1)			ST1-12-1				
x_i		y_i		z_i		delete		INIT	

 TEXAS INSTRUMENTS				
ST1-12-2		B $\blacktriangleright$ M'TIPLE LIN REGRESSION (2)		
		A $\blacktriangleleft$ M'TIPLE LIN REGRESSION (2)		
		ST1-12-2		
a_0	a_1	a_2	x	$y \rightarrow z'$

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program ST1-12-1					
2	Initialize		E			0.
3	Enter data	x_i	A			x_i
	(repeat for all i)	y_i	B			y_i
		z_i	C			n
4	Delete data					
	a. Enter x	x	A			x
	b. Enter y	y	B			y
	c. Enter z	z	D			n-1
5	The stored sums may		RCL	0	0	n
	be recalled, if desired		RCL	0	1	Σx_i
			RCL	0	2	Σy_i
			RCL	0	3	Σz_i
			RCL	0	4	Σx_i^2
			RCL	0	5	Σy_i^2
			RCL	0	6	$\Sigma x_i y_i$
			RCL	0	7	$\Sigma x_i z_i$
			RCL	0	8	$\Sigma y_i z_i$
6	Enter Program ST1-12-2					
7	Calculate regression		A			a_0
	coefficients		B			a_1
			C			a_2
8	Compute estimated	x	D			x
	value for z' given x and y	y	E			z'
	(must be done after step 7)					

PROGRAM LISTING

DISK #	KEY	DISK #	KEY	DISK #	KEY	DISK #	KEY
000 48 LBL	058 43 RCL	058 43 RCL	058 43 RCL	058 43 RCL	058 43 RCL	058 43 RCL	058 43 RCL
001 12 E	059 01 1	059 01 1	059 01 1	059 01 1	059 01 1	059 01 1	059 01 1
002 47 CMC	060 03 3	060 03 3	060 03 3	060 03 3	060 03 3	060 03 3	060 03 3
003 25 CLR	061 48 PROD	061 48 PROD	061 48 PROD	061 48 PROD	061 48 PROD	061 48 PROD	061 48 PROD
004 56 r/n	062 01 1	062 01 1	062 01 1	062 01 1	062 01 1	062 01 1	062 01 1
005 46 LBL	063 04 4	063 04 4	063 04 4	063 04 4	063 04 4	063 04 4	063 04 4
006 11 A	064 44 SUM	064 44 SUM	064 44 SUM	064 44 SUM	064 44 SUM	064 44 SUM	064 44 SUM
007 42 STO	065 00 0	065 00 0	065 00 0	065 00 0	065 00 0	065 00 0	065 00 0
008 01 1	066 05 5	066 05 5	066 05 5	066 05 5	066 05 5	066 05 5	066 05 5
009 02 2	067 42 STO	067 42 STO	067 42 STO	067 42 STO	067 42 STO	067 42 STO	067 42 STO
010 56 r/n	068 01 1	068 01 1	068 01 1	068 01 1	068 01 1	068 01 1	068 01 1
011 46 LBL	069 06 6	069 06 6	069 06 6	069 06 6	069 06 6	069 06 6	069 06 6
012 12 B	070 40 X	070 40 X	070 40 X	070 40 X	070 40 X	070 40 X	070 40 X
013 42 STO	071 44 SUM	071 44 SUM	071 44 SUM	071 44 SUM	071 44 SUM	071 44 SUM	071 44 SUM
014 01 1	072 00 0	072 00 0	072 00 0	072 00 0	072 00 0	072 00 0	072 00 0
015 03 3	073 08 8	073 08 8	073 08 8	073 08 8	073 08 8	073 08 8	073 08 8
016 56 r/n	074 42 RCL	074 42 RCL	074 42 RCL	074 42 RCL	074 42 RCL	074 42 RCL	074 42 RCL
017 46 LBL	075 01 1	075 01 1	075 01 1	075 01 1	075 01 1	075 01 1	075 01 1
018 12 C	076 02 2	076 02 2	076 02 2	076 02 2	076 02 2	076 02 2	076 02 2
019 44 SUM	077 48 PROD	077 48 PROD	077 48 PROD	077 48 PROD	077 48 PROD	077 48 PROD	077 48 PROD
020 00 0	078 01 1	078 01 1	078 01 1	078 01 1	078 01 1	078 01 1	078 01 1
021 03 3	079 08 8	079 08 8	079 08 8	079 08 8	079 08 8	079 08 8	079 08 8
022 42 STO	080 48 PROD	080 48 PROD	080 48 PROD	080 48 PROD	080 48 PROD	080 48 PROD	080 48 PROD
023 01 1	081 01 1	081 01 1	081 01 1	081 01 1	081 01 1	081 01 1	081 01 1
024 08 8	082 06 6	082 06 6	082 06 6	082 06 6	082 06 6	082 06 6	082 06 6
025 42 STO	083 44 SUM	083 44 SUM	083 44 SUM	083 44 SUM	083 44 SUM	083 44 SUM	083 44 SUM
026 01 1	084 00 0	084 00 0	084 00 0	084 00 0	084 00 0	084 00 0	084 00 0
027 04 4	085 01 1	085 01 1	085 01 1	085 01 1	085 01 1	085 01 1	085 01 1

REGISTERS

00 24	01 24	02 24	03 24	04 24
05 24	06 24	07 24	08 24	09 24
10 24	11 24	12 24	13 24	14 24
15 24	16 24	17 24	18 24	19 24
20 24	21 24	22 24	23 24	24 24

FLAGS

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 43 RCL		056 40 *x ²		084 43 RCL	
001 15 E		029 01 1		057 44 SUM		085 00 0	
002 47 *CMs		030 03 3		058 00 0		086 00 0	
003 25 CLR		031 49 *PROD		059 04 4		087 56 *rtn	
004 56 *rtn		032 01 1		060 43 RCL		088 46 *LBL	
005 46 *LBL		033 04 4		061 01 1		089 14 D	
006 11 A		034 44 SUM		062 06 6		090 22 INV	
007 42 STO		035 00 0		063 44 SUM		091 44 SUM	
008 01 1		036 02 2		064 00 0		092 00 0	
009 02 2		037 42 STO		065 06 6		093 03 3	
010 56 *rtn		038 01 1		066 43 RCL		094 42 STO	
011 46 *LBL		039 06 6		067 01 1		095 01 1	
012 12 B		040 40 *x ²		068 05 5		096 05 5	
013 42 STO		041 44 SUM		069 44 SUM		097 42 STO	
014 01 1		042 00 0		070 00 0		098 01 1	
015 03 3		043 05 5		071 07 7		099 04 4	
016 56 *rtn		044 43 RCL		072 43 RCL		100 43 RCL	
017 46 *LBL		045 01 1		073 01 1		101 01 1	
018 13 C		046 02 2		074 04 4		102 03 3	
019 44 SUM		047 49 *PROD		075 44 SUM		103 49 *PROD	
020 00 0		048 01 1		076 00 0		104 01 1	
021 03 3		049 05 5		077 08 8		105 04 4	
022 42 STO		050 49 *PROD		078 01 1		106 22 INV	
023 01 1		051 01 1		079 46 *LBL		107 44 SUM	
024 05 5		052 06 6		080 87 *1'		108 00 0	
025 42 STO		053 44 SUM		081 44 SUM		109 02 2	
026 01 1		054 00 0		082 00 0		110 42 STO	
027 04 4		055 01 1		083 00 0		111 01 1	

*Denotes 2nd function key

REGISTERS

00 n	05 Σy_i^2	10	15
01 Σx_i	06 $\Sigma x_i y_i$	11	16
02 Σy_i	07 $\Sigma x_i z_i$	12	17
03 Σz_i	08 $\Sigma y_i z_i$	13	18
04 Σx_i^2	09	14	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 06 6		140 44 SUM		168 00		196 00	
113 40 *x ²		141 00 0		169 00		197 00	
114 22 INV		142 06 6		170 00		198 00	
115 44 SUM		143 43 RCL		171 00		199 00	
116 00 0		144 01 1		172 00		200 00	
117 05 5		145 05 5		173 00		201 00	
118 43 RCL		146 22 INV		174 00		202 00	
119 01 1		147 44 SUM		175 00		203 00	
120 02 2		148 00 0		176 00		204 00	
121 49 *PROD		149 07 7		177 00		205 00	
122 01 1		150 43 RCL		178 00		206 00	
123 05 5		151 01 1		179 00		207 00	
124 49 *PROD		152 04 4		180 00		208 00	
125 01 1		153 22 INV		181 00		209 00	
126 06 6		154 44 SUM		182 00		210 00	
127 22 INV		155 00 0		183 00		211 00	
128 44 SUM		156 08 8		184 00		212 00	
129 00 0		157 01 1		185 00		213 00	
130 01 1		158 94 +/—		186 00		214 00	
131 40 *x ²		159 41 GTO		187 00		215 00	
132 22 INV		160 87 *1'		188 00		216 00	
133 44 SUM		161 00		189 00		217 00	
134 00 0		162 00		190 00		218 00	
135 04 4		163 00		191 00		219 00	
136 43 RCL		164 00		192 00		220 00	
137 01 1		165 00		193 00		221 00	
138 06 6		166 00		194 00		222 00	
139 22 INV		167 00		195 00		223 00	

*Denotes 2nd function key

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 43 RCL		056 20 *1/x		084 43 RCL	
001 11 A		029 00 0		057 70 *if err		085 01 1	
002 43 RCL		030 02 2		058 97 *list		086 05 5	
003 00 0		031 40 *x ²		059 65 X		087 65 X	
004 00 0		032 54)		060 53 (		088 53 (	
005 65 X		033 75 —		061 43 RCL		089 43 RCL	
006 43 RCL		034 53 (		062 01 1		090 00 0	
007 00 0		035 43 RCL		063 04 4		091 00 0	
008 04 4		036 00 0		064 65 X		092 65 X	
009 75 —		037 00 0		065 53 (		093 43 RCL	
010 43 RCL		038 65 X		066 43 RCL		094 00 0	
011 00 0		039 43 RCL		067 00 0		095 07 7	
012 01 1		040 00 0		068 00 0		096 75 —	
013 40 *x ²		041 06 6		069 65 X		097 43 RCL	
014 95 =		042 75 —		070 43 RCL		098 00 0	
015 42 STO		043 43 RCL		071 00 0		099 01 1	
016 01 1		044 00 0		072 08 8		100 65 X	
017 04 4		045 01 1		073 75 —		101 43 RCL	
018 65 X		046 65 X		074 43 RCL		102 00 0	
019 53 (		047 43 RCL		075 00 0		103 03 3	
020 43 RCL		048 00 0		076 02 2		104 54)	
021 00 0		049 02 2		077 65 X		105 42 STO	
022 00 0		050 54)		078 43 RCL		106 01 1	
023 65 X		051 42 STO		079 00 0		107 06 6	
024 43 RCL		052 01 1		080 03 3		108 95 =	
025 00 0		053 05 5		081 54)		109 42 STO	
026 05 5		054 40 *x ²		082 75 —		110 01 1	
027 75 —		055 95 =		083 53 (		111 01 1	

*Denotes 2nd function key

REGISTERS

00 n	05 $\sum y_i^2$	10 a_1	15 Used
01 $\sum x_i$	06 $\sum x_i y_i$	11 a_2	16 Used
02 $\sum y_i$	07 $\sum x_i z_i$	12 z'	17
03 $\sum z_i$	08 $\sum y_i z_i$	13 Used	18
04 $\sum x_i^2$	09 a_0	14 Used	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 65 X		140 43 RCL		168 13 C		196 09 9	
113 43 RCL		141 01 1		169 43 RCL		197 95 =	
114 01 1		142 01 1		170 01 1		198 41 GTO	
115 05 5		143 65 X		171 01 1		199 14 D	
116 94 +/-		144 43 RCL		172 56 *rtn		200 00	
117 85 +		145 00 0		173 46 *LBL		201 00	
118 43 RCL		146 02 2		174 14 D		202 00	
119 01 1		147 95 =		175 42 STO		203 00	
120 06 6		148 55 ÷		176 01 1		204 00	
121 95 =		149 43 RCL		177 02 2		205 00	
122 55 ÷		150 00 0		178 56 *rtn		206 00	
123 43 RCL		151 00 0		179 46 *LBL		207 00	
124 01 1		152 95 =		180 15 E		208 00	
125 04 4		153 42 STO		181 65 X		209 00	
126 95 =		154 00 0		182 43 RCL		210 00	
127 42 STO		155 09 9		183 01 1		211 00	
128 01 1		156 56 *rtn		184 01 1		212 00	
129 00 0		157 46 *LBL		185 85 +		213 00	
130 65 X		158 97 *list		186 43 RCL		214 00	
131 43 RCL		159 00 0		187 01 1		215 00	
132 00 0		160 56 *rtn		188 02 2		216 00	
133 01 1		161 46 *LBL		189 65 X		217 00	
134 94 +/-		162 12 B		190 43 RCL		218 00	
135 85 +		163 43 RCL		191 01 1		219 00	
136 43 RCL		164 01 1		192 00 0		220 00	
137 00 0		165 00 0		193 85 +		221 00	
138 03 3		166 56 *rtn		194 43 RCL		222 00	
139 75 -		167 46 *LBL		195 00 0		223 00	

*Denotes 2nd function key

QUADRATIC REGRESSION

The quadratic equation

$$y = a_2x^2 + a_1x + a_0$$

with normal equations

$$\sum_{i=1}^n y_i = a_2 \sum_{i=1}^n x_i^2 + a_1 \sum_{i=1}^n x_i + a_0 n$$

$$\sum_{i=1}^n x_i y_i = a_2 \sum_{i=1}^n x_i^3 + a_1 \sum_{i=1}^n x_i^2 + a_0 \sum_{i=1}^n x_i$$

$$\sum_{i=1}^n x_i^2 y_i = a_2 \sum_{i=1}^n x_i^4 + a_1 \sum_{i=1}^n x_i^3 + a_0 \sum_{i=1}^n x_i^2$$

is used to approximate functions of a single variable whose true form is not known, where

n = number of (x,y) points ($n = 3,4,5,\dots$)

Also, for a given x , this program will calculate

$$y(x) = a_2x^2 + a_1x + a_0$$

Where: a_2 , a_1 , and a_0 are determined from the normal equations.

NOTES: 1. To delete an x,y pair, enter x on A and y on C. The displayed count, n , will be reduced by 1. If you attempt to delete an x,y pair before data has been entered, -1 will flash in the display.

2. If x_i is not entered, it will automatically be assigned the value of n when y_i is entered.

Reference: *Computer Methods for Science and Engineering*, Robert L. LaFara, Hayden Book Co., 1973

Example: Given the sample:

x	0	1	2	3	4	5	6	7	8
y	3.2	2	1.2	.5	1	2	2.9	4	6.6

find a_2 , a_1 , a_0 , and $y(6.2)$.

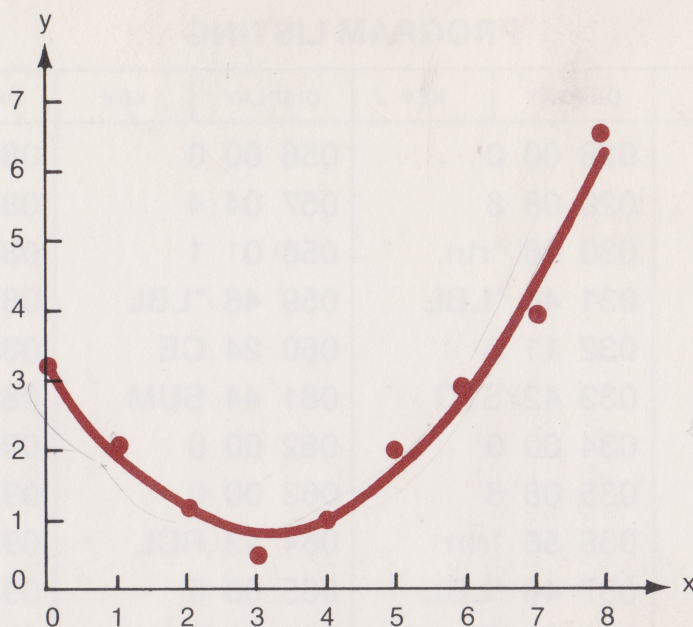
$$a_2 = .2392857143$$

$$a_1 = -1.505952381$$

$$a_0 = 3.2$$

Thus, $y = .2392857143x^2 - 1.505952381x + 3.2$

and $y(6.2) = 3.061238095$



 TEXAS INSTRUMENTS				
ST1-13-1		B $\blacktriangleright$ QUADRATIC REGRESSION(1)		
A $\blacktriangleleft$ QUADRATIC REGRESSION(1)		ST1-13-1		
x_i	y_i	delete	INIT	

 TEXAS INSTRUMENTS				
ST1-13-2		B $\blacktriangleright$ QUADRATIC REGRESSION(2)		
A $\blacktriangleleft$ QUADRATIC REGRESSION(2)		ST1-13-2		
a_0	a_1	a_2	$x \rightarrow y'$	

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program ST1-13-1	(A+B)				
2	Initialize		E			0.
3	Enter data	x_i (year)	A			x_i
		y_i (data)	B			n
	(repeat for all i)					
4	Delete data	x_i	A			x_i
		y_i	C			n
5	Enter Program ST1-13-2	(A+B)				
6	Calculate a_0, a_1, a_2		A			a_0
7	Display a_1		B			a_1
8	Display a_2		C			a_2
9	Calculate $y = f(x)$	$x \rightarrow$	D			y

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 56 *rtn		028 00 0		056 00 0		084 94 +/-	
001 46 *LBL		029 08 8		057 04 4		085 17 *B'	
002 15 E		030 56 *rtn		058 01 1		086 94 +/-	
003 47 *CMs		031 46 *LBL		059 46 *LBL		087 44 SUM	
004 25 CLR		032 11 A		060 24 CE		088 00 0	
005 86 *rset		033 42 STO		061 44 SUM		089 01 1	
006 46 *LBL		034 00 0		062 00 0		090 40 *x ²	
007 16 *A'		035 08 8		063 00 0		091 94 +/-	
008 65 X		036 56 *rtn		064 43 RCL		092 44 SUM	
009 43 RCL		037 46 *LBL		065 00 0		093 00 0	
010 00 0		038 12 B		066 00 0		094 02 2	
011 08 8		039 42 STO		067 42 STO		095 40 *x ²	
012 95 =		040 00 0		068 00 0		096 94 +/-	
013 56 *rtn		041 09 9		069 08 8		097 44 SUM	
014 46 *LBL		042 17 *B'		070 56 *rtn		098 00 0	
015 17 *B'		043 44 SUM		071 46 *LBL		099 04 4	
016 44 SUM		044 00 0		072 13 C		100 43 RCL	
017 00 0		045 01 1		073 42 STO		101 00 0	
018 05 5		046 40 *x ²		074 00 0		102 08 8	
019 16 *A'		047 44 SUM		075 09 9		103 40 *x ²	
020 44 SUM		048 00 0		076 43 RCL		104 16 *A'	
021 00 0		049 02 2		077 00 0		105 94 +/-	
022 06 6		050 16 *A'		078 00 0		106 44 SUM	
023 16 *A'		051 44 SUM		079 90 *if zro		107 00 0	
024 44 SUM		052 00 0		080 52 EE		108 03 3	
025 00 0		053 03 3		081 43 RCL		109 01 1	
026 07 7		054 16 *A'		082 00 0		110 94 +/-	
027 43 RCL		055 44 SUM		083 09 9		111 41 GTO	

*Denotes 2nd function key

REGISTERS

00 n	05 Σy	10	15
01 Σx	06 Σxy	11	16
02 Σx^2	07 $\Sigma x^2 y$	12	17
03 Σx^3	08 x	13	18
04 Σx^4	09 y	14	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 24 CE		140 00		168 00		196 00	
113 46 *LBL		141 00		169 00		197 00	
114 52 EE		142 00		170 00		198 00	
115 20 *1/x		143 00		171 00		199 00	
116 01 1		144 00		172 00		200 00	
117 94 +/-		145 00		173 00		201 00	
118 56 *rtn		146 00		174 00		202 00	
119 00		147 00		175 00		203 00	
120 00		148 00		176 00		204 00	
121 00		149 00		177 00		205 00	
122 00		150 00		178 00		206 00	
123 00		151 00		179 00		207 00	
124 00		152 00		180 00		208 00	
125 00		153 00		181 00		209 00	
126 00		154 00		182 00		210 00	
127 00		155 00		183 00		211 00	
128 00		156 00		184 00		212 00	
129 00		157 00		185 00		213 00	
130 00		158 00		186 00		214 00	
131 00		159 00		187 00		215 00	
132 00		160 00		188 00		216 00	
133 00		161 00		189 00		217 00	
134 00		162 00		190 00		218 00	
135 00		163 00		191 00		219 00	
136 00		164 00		192 00		220 00	
137 00		165 00		193 00		221 00	
138 00		166 00		194 00		222 00	
139 00		167 00		195 00		223 00	

*Denotes 2nd function key

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 43 RCL		056 20 *1/x		084 43 RCL	
001 11 A		029 00 0		057 70 *if err		085 01 1	
002 43 RCL		030 02 2		058 97 *list		086 05 5	
003 00 0		031 40 *x ²		059 65 X		087 65 X	
004 00 0		032 54)		060 53 (		088 53 (	
005 65 X		033 75 —		061 43 RCL		089 43 RCL	
006 43 RCL		034 53 (		062 01 1		090 00 0	
007 00 0		035 43 RCL		063 04 4		091 00 0	
008 02 2		036 00 0		064 65 X		092 65 X	
009 75 —		037 00 0		065 53 (		093 43 RCL	
010 43 RCL		038 65 X		066 43 RCL		094 00 0	
011 00 0		039 43 RCL		067 00 0		095 06 6	
012 01 1		040 00 0		068 00 0		096 75 —	
013 40 *x ²		041 03 3		069 65 X		097 43 RCL	
014 95 =		042 75 —		070 43 RCL		098 00 0	
015 42 STO		043 43 RCL		071 00 0		099 01 1	
016 01 1		044 00 0		072 07 7		100 65 X	
017 04 4		045 01 1		073 75 —		101 43 RCL	
018 65 X		046 65 X		074 43 RCL		102 00 0	
019 53 (		047 43 RCL		075 00 0		103 05 5	
020 43 RCL		048 00 0		076 02 2		104 54)	
021 00 0		049 02 2		077 65 X		105 42 STO	
022 00 0		050 54)		078 43 RCL		106 01 1	
023 65 X		051 42 STO		079 00 0		107 06 6	
024 43 RCL		052 01 1		080 05 5		108 95 =	
025 00 0		053 05 5		081 54)		109 42 STO	
026 04 4		054 40 *x ²		082 75 —		110 01 1	
027 75 —		055 95 =		083 53 (		111 01 1	

*Denotes 2nd function key

REGISTERS

00 n	05 Σy	10 a_1	15 Used
01 Σx	06 Σxy	11 a_2	16 Used
02 Σx^2	07 $\Sigma x^2 y$	12 y'	17
03 Σx^3	08 x	13	18
04 Σx^4	09 a_0	14 Used	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 65 X		140 43 RCL		168 13 C		196 42 STO	
113 43 RCL		141 01 1		169 43 RCL		197 01 1	
114 01 1		142 01 1		170 01 1		198 02 2	
115 05 5		143 65 X		171 01 1		199 56 *rtn	
116 94 +/-		144 43 RCL		172 56 *rtn		200 00	
117 85 +		145 00 0		173 46 *LBL		201 00	
118 43 RCL		146 02 2		174 14 D		202 00	
119 01 1		147 95 =		175 42 STO		203 00	
120 06 6		148 55 ÷		176 01 1		204 00	
121 95 =		149 43 RCL		177 02 2		205 00	
122 55 ÷		150 00 0		178 40 *x ²		206 00	
123 43 RCL		151 00 0		179 65 X		207 00	
124 01 1		152 95 =		180 43 RCL		208 00	
125 04 4		153 42 STO		181 01 1		209 00	
126 95 =		154 00 0		182 01 1		210 00	
127 42 STO		155 09 9		183 85 +		211 00	
128 01 1		156 56 *rtn		184 43 RCL		212 00	
129 00 0		157 46 *LBL		185 01 1		213 00	
130 65 X		158 97 *list		186 02 2		214 00	
131 43 RCL		159 00 0		187 65 X		215 00	
132 00 0		160 56 *rtn		188 43 RCL		216 00	
133 01 1		161 46 *LBL		189 01 1		217 00	
134 94 +/-		162 12 B		190 00 0		218 00	
135 85 +		163 43 RCL		191 85 +		219 00	
136 43 RCL		164 01 1		192 43 RCL		220 00	
137 00 0		165 00 0		193 00 0		221 00	
138 05 5		166 56 *rtn		194 09 9		222 00	
139 75 -		167 46 *LBL		195 95 =		223 00	

*Denotes 2nd function key

HISTOGRAM CONSTRUCTION

This program constructs a histogram, given the range ($x_{\min}$ to $x_{\max}$) and the individual observed values (x_i) of a variable. Each data value entered is checked against the range, and those meeting the criteria

$$x_{\min} \leq x_i < x_{\max}$$

are placed in the appropriate class interval (cell) by the algorithm:

$$\text{Class Interval (Cell No.)} = \text{INT} \left[\left(12 \frac{x_i - x_{\min}}{x_{\max} - x_{\min}} \right) + 0.5 \right]$$

A data value falling outside the specified range is discarded when entered and this condition is indicated by a flashing-nines display. The maximum allowable data range is 10^{-9} to 10^9 .

Outputs of the program are:

n = total number of x_i entered within the range specified

m = mean value of the $x_i = \frac{\sum x_i}{n}$

σ^2 = variance of the $x_i = \frac{1}{n} \left[\sum x_i^2 - \frac{(\sum x_i)^2}{n} \right]$

f_j = frequency of class interval (cell) $j = \frac{N_j}{n}$

where N_j = number of items in cell j

U_j = upper limit of cell $j = \left(\frac{x_{\max} - x_{\min}}{12} \right) j + x_{\min}$

If all entries occur in one cell, then the frequency is 1 and the cell number which is added to the frequency before display, will appear to be one greater than it should be; that is, if all observations fall in cell 7, the frequency of cell 7 will be displayed as 8.000.

Example: $x_{\min} = -6$, $x_{\max} = 6$

Data values: $-6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5$

Number of entries = $n = 12$ (in the range $x_{\min} \leq x < x_{\max}$)

Mean = $m = -0.5$

Variance = $\sigma^2 = 11.91666667$

Frequency and upper limit versus cell number:

Cell No.	1	2	3	4	5	6
Frequency	.083	.083	.083	.083	.083	.083
Upper Limit	-5.000	-4.000	-3.000	-2.000	-1.000	0.000
Cell No.	7	8	9	10	11	12
Frequency	.083	.083	.083	.083	.083	.083
Upper Limit	1.000	2.000	3.000	4.000	5.000	6.000

ST1-14

►► B ■ HISTOGRAM CONSTRUCTION

◀A▶ HISTOGRAM CONSTRUCTION

ST1-14

n	mean	σ^2	del x	UL
INIT	x (min)	x (max)	x_i	freq

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Initialize		A			0.
3	Enter lower limit	$x_{\min}$	B			$x_{\min}$
4	Enter upper limit	$x_{\max}$	C			$x_{\max}$
5	Enter data	x_i	D			x_i
6	Delete data	x	2nd	D'		x
7	Display total count		2nd	A'		n
8	Display mean		2nd	B'		m
9	Display variance		2nd	C'		σ^2
10	Display frequency		E			cc.fff
11	Display upper limit of		2nd	E'		dd.ddd
	cell of step 10					

2) Step 11 must be performed immediately following step 10 for the cell in question.

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 56 *rtn		028 29 *x!		056 00 0		084 01 1	
001 46 *LBL		029 46 *LBL		057 01 1		085 08 8	
002 14 D		030 65 X		058 60 *if flg		086 00 0	
003 50 *st flg		031 00 0		059 01 1		087 42 STO	
004 01 1		032 20 *1/x		060 55 ÷		088 00 0	
005 46 *LBL		033 86 *rset		061 94 +/—		089 00 0	
006 19 *D'		034 46 *LBL		062 46 *LBL		090 22 INV	
007 42 STO		035 29 *x!		063 55 ÷		091 50 *st flg	
008 01 1		036 65 X		064 36 *IND		092 01 1	
009 06 6		037 43 RCL		065 44 SUM		093 43 RCL	
010 94 +/—		038 01 1		066 00 0		094 01 1	
011 85 +		039 03 3		067 00 0		095 06 6	
012 43 RCL		040 20 *1/x		068 44 SUM		096 56 *rtn	
013 01 1		041 85 +		069 01 1		097 46 *LBL	
014 04 4		042 93 •		070 09 9		098 15 E	
015 95 =		043 05 5		071 65 X		099 01 1	
016 23 ln x		044 57 *fix		072 43 RCL		100 44 SUM	
017 70 *if err		045 00 0		073 01 1		101 00 0	
018 65 X		046 95 =		074 06 6		102 00 0	
019 43 RCL		047 22 INV		075 65 X		103 01 1	
020 01 1		048 52 EE		076 44 SUM		104 02 2	
021 06 6		049 52 EE		077 01 1		105 75 —	
022 75 —		050 22 INV		078 07 7		106 43 RCL	
023 43 RCL		051 52 EE		079 43 RCL		107 00 0	
024 01 1		052 57 *fix		080 01 1		108 00 0	
025 05 5		053 09 9		081 06 6		109 95 =	
026 95 =		054 42 STO		082 95 =		110 80 *if pos	
027 80 *if pos		055 00 0		083 44 SUM		111 59 *π	

*Denotes 2nd function key

REGISTERS

00 cell #	05 cell 5	10 cell 10	15 x(min)
01 cell 1	06 cell 6	11 cell 11	16 x_i
02 cell 2	07 cell 7	12 cell 12	17 Σx
03 cell 3	08 cell 8	13 cell width	18 Σx^2
04 cell 4	09 cell 9	14 x(max)	19 Total Count

FLAGS

0	1 Used	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 01 1		140 86 *rset		168 43 RCL		196 01 1	
113 42 STO		141 46 *LBL		169 01 1		197 09 9	
114 00 0		142 10 *E'		170 05 5		198 95 =	
115 00 0		143 43 RCL		171 95 =		199 56 *rtn	
116 46 *LBL		144 01 1		172 55 ÷		200 46 *LBL	
117 59 * π		145 03 3		173 01 1		201 18 *C'	
118 36 *IND		146 65 X		174 02 2		202 17 *B'	
119 43 RCL		147 43 RCL		175 95 =		203 65 X	
120 00 0		148 00 0		176 42 STO		204 43 RCL	
121 00 0		149 00 0		177 01 1		205 01 1	
122 55 ÷		150 85 +		178 03 3		206 07 7	
123 43 RCL		151 43 RCL		179 43 RCL		207 95 =	
124 01 1		152 01 1		180 01 1		208 94 +/-	
125 09 9		153 05 5		181 04 4		209 85 +	
126 85 +		154 95 =		182 56 *rtn		210 43 RCL	
127 43 RCL		155 56 *rtn		183 46 *LBL		211 01 1	
128 00 0		156 46 *LBL		184 16 *A'		212 08 8	
129 00 0		157 12 B		185 43 RCL		213 95 =	
130 95 =		158 42 STO		186 01 1		214 55 ÷	
131 57 *fix		159 01 1		187 09 9		215 43 RCL	
132 03 3		160 05 5		188 56 *rtn		216 01 1	
133 56 *rtn		161 56 *rtn		189 46 *LBL		217 09 9	
134 46 *LBL		162 46 *LBL		190 17 *B'		218 95 =	
135 11 A		163 13 C		191 43 RCL		219 56 *rtn	
136 57 *fix		164 43 STO		192 01 1		220 00	
137 09 9		165 01 1		193 07 7		221 00	
138 47 *CMs		166 04 4		194 55 ÷		222 00	
139 25 CLR		167 75 -		195 43 RCL		223 00	

*Denotes 2nd function key

NORMAL DISTRIBUTION

In order to calculate the standard normal distribution, the following probability function is used:

$$Z(x) = \frac{1}{\sqrt{2\pi}} e^{-x^2/2}$$

Then: $Q(x) = Z(x)(b_1t + b_2t^2 + b_3t^3 + b_4t^4 + b_5t^5) + \epsilon(x)$

Where: $t = \frac{1}{1 + px}$
 $|\epsilon(x)| < 7.5 \times 10^{-8}$

$$p = .2316419$$

$$b_1 = .319381530$$

$$b_2 = -.356563782$$

$$b_3 = 1.781477937$$

$$b_4 = -1.821255978$$

$$b_5 = 1.330274429$$

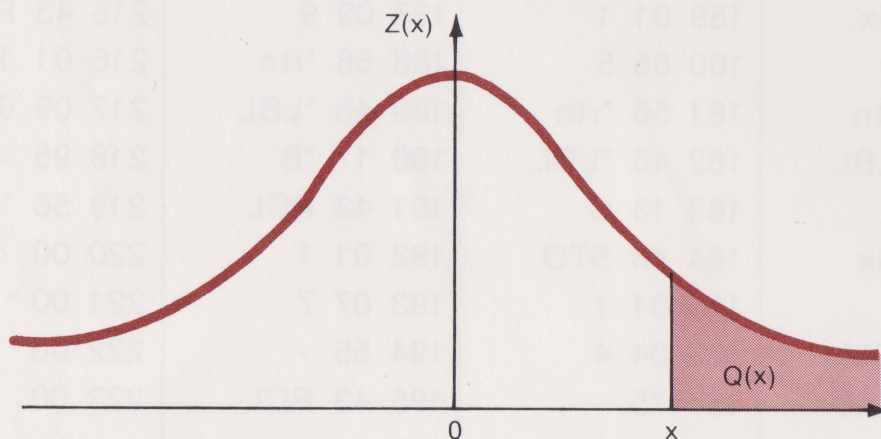
NOTES: 1. $Z(-x) = Z(x)$, $P(x) = 1 - Q(x)$

2. $|x| < 21.0917$

3. $Z(x)$ must be calculated before $Q(x)$

Reference: *Handbook of Mathematical Functions*, National Bureau of Standards, 1964.

Example: For $x = 2.02$, $Z(x) = .0518635767$, $Q(x) = .0216916245$



 TEXAS INSTRUMENTS				
ST1-15		◀B▶ NORMAL DISTRIBUTION		
◀A▶ NORMAL DISTRIBUTION				ST1-15
$x \rightarrow Z(x)$		$Q(x)$		

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Enter data	x	A			Z(x)
3	Calculate Q(x)		B			Q(x)

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 30 $\sqrt{x}$		056 65 X		084 43 RCL	
001 11 A		029 95 =		057 93 •		085 00 0	
002 22 INV		030 42 STO		058 03 3		086 02 2	
003 50 *st flg		031 00 0		059 01 1		087 45 y^x	
004 01 1		032 01 1		060 09 9		088 03 3	
005 80 *if pos		033 56 *rtn		061 03 3		089 65 X	
006 87 *1'		034 46 *LBL		062 08 8		090 01 1	
007 94 +/—		035 12 B		063 01 1		091 93 •	
008 50 *st flg		036 25 CLR		064 05 5		092 07 7	
009 01 1		037 93 •		065 03 3		093 08 8	
010 46 *LBL		038 02 2		066 75 —		094 01 1	
011 87 *1'		039 03 3		067 43 RCL		095 04 4	
012 42 STO		040 01 1		068 00 0		096 07 7	
013 00 0		041 06 6		069 02 2		097 07 7	
014 00 0		042 04 4		070 45 y^x		098 09 9	
015 40 x^2		043 01 1		071 02 2		099 03 3	
016 55 ÷		044 09 9		072 65 X		100 07 7	
017 02 2		045 65 X		073 93 •		101 75 —	
018 95 =		046 43 RCL		074 03 3		102 43 RCL	
019 94 +/—		047 00 0		075 05 5		103 00 0	
020 22 INV		048 00 0		076 06 6		104 02 2	
021 23 $\ln x$		049 85 +		077 05 5		105 45 y^x	
022 55 ÷		050 01 1		078 06 6		106 04 4	
023 53 (		051 95 =		079 03 3		107 65 X	
024 59 π		052 20 $1/x$		080 07 7		108 01 1	
025 65 X		053 42 STO		081 08 8		109 93 •	
026 02 2		054 00 0		082 02 2		110 08 8	
027 54)		055 02 2		083 85 +		111 02 2	

*Denotes 2nd function key

REGISTERS

00 Used	05	10	15
01 Used	06	11	16
02 Used	07	12	17
03	08	13	18
04	09	14	19

FLAGS

0	1 Used	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 01 1		140 00 0		168 00		196 00	
113 02 2		141 01 1		169 00		197 00	
114 05 5		142 95 =		170 00		198 00	
115 05 5		143 60 *if flg		171 00		199 00	
116 09 9		144 01 1		172 00		200 00	
117 07 7		145 69 *9'		173 00		201 00	
118 08 8		146 56 *rtn		174 00		202 00	
119 85 +		147 46 *LBL		175 00		203 00	
120 43 RCL		148 69 *9'		176 00		204 00	
121 00 0		149 94 +/-		177 00		205 00	
122 02 2		150 85 +		178 00		206 00	
123 45 y ^x		151 01 1		179 00		207 00	
124 05 5		152 95 =		180 00		208 00	
125 65 X		153 56 *rtn		181 00		209 00	
126 01 1		154 00		182 00		210 00	
127 93 •		155 00		183 00		211 00	
128 03 3		156 00		184 00		212 00	
129 03 3		157 00		185 00		213 00	
130 00 0		158 00		186 00		214 00	
131 02 2		159 00		187 00		215 00	
132 07 7		160 00		188 00		216 00	
133 04 4		161 00		189 00		217 00	
134 04 4		162 00		190 00		218 00	
135 02 2		163 00		191 00		219 00	
136 09 9		164 00		192 00		220 00	
137 95 =		165 00		193 00		221 00	
138 65 X		166 00		194 00		222 00	
139 43 RCL		167 00		195 00		223 00	

*Denotes 2nd function key

CHI-SQUARE DISTRIBUTION

The chi-square density function is calculated by

$$p_x f(x) = \frac{e^{-\frac{x}{2}} x^{\left(\frac{\nu}{2}-1\right)}}{2^{\frac{\nu}{2}} \Gamma\left(\frac{\nu}{2}\right)}$$

where ν = degrees of freedom, $0 < \nu \leq 141$, $x > 0$ and $\ln x \leq \frac{200 \ln 10}{(\nu - 2)}$

The following series expansion calculates the cumulative distribution:

$$P(x|\nu) = \left(\frac{x}{2}\right)^{\frac{\nu}{2}} \frac{e^{-\frac{x}{2}}}{\Gamma\left(\frac{\nu+2}{2}\right)} \left[1 + \sum_{r=1}^{\infty} \frac{x^r}{(\nu+2)(\nu+4) \dots (\nu+2r)}\right]$$

Where: $\Gamma(\nu+1) = \nu\Gamma(\nu) = \nu! = \nu(\nu-1)!$

and $\Gamma\left(\frac{1}{2}\right) = \sqrt{\pi}$

- NOTES:
1. If the degrees of freedom is entered as a non-integer, it is rounded up to an integer for the calculation.
 2. If ν or x is negative or zero, a flashing 0 is returned.
 3. A ν must be entered before an x , and both must be entered before P is calculated.
 4. A new x may be entered without changing ν .
 5. An x must be entered each time P is to be calculated.

Example: For $\nu = 10$, $\Gamma\left(\frac{\nu}{2}\right) = 24$ and if $x = 8.5$, $f(x) = .0969533757$, and $P = .4198816863$

Reference: *An Introduction to Probability and Stochastic Processes*; James L. Melsa, Andrew P. Sage; Prentice-Hall Electrical Eng. Series, 1973

 TEXAS INSTRUMENTS				
ST1-16 CHI-SQUARE DISTRIBUTION				
A CHI-SQUARE DISTRIBUTION ST1-16				
$\nu \rightarrow \Gamma(\nu/2)$	$x \rightarrow f(x)$	P		

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Enter degrees of freedom	ν	A			$\Gamma(\frac{\nu}{2})$
3	Enter x	x	B			f(x)
4	Calculate P		C			P

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 75 -		056 04 4		084 52 EE	
001 43 RCL		029 48 *EXC		057 49 *PROD		085 57 *fix	
002 02 2		030 00 0		058 00 0		086 00 0	
003 44 SUM		031 06 6		059 03 3		087 52 EE	
004 00 0		032 95 =		060 46 *LBL		088 22 INV	
005 08 8		033 22 INV		061 42 STO		089 52 EE	
006 43 RCL		034 90 *if zro		062 43 RCL		090 57 *fix	
007 00 0		035 43 RCL		063 00 0		091 09 9	
008 02 2		036 43 RCL		064 04 4		092 22 INV	
009 55 ÷		037 00 0		065 75 -		093 80 *if pos	
010 43 RCL		038 06 6		066 93 •		094 10 *E'	
011 00 0		039 49 *PROD		067 05 5		095 90 *if zro	
012 08 8		040 00 0		068 95 =		096 10 *E'	
013 65 X		041 05 5		069 22 INV		097 42 STO	
014 43 RCL		042 43 RCL		070 90 *if zro		098 00 0	
015 00 0		043 00 0		071 44 SUM		099 07 7	
016 04 4		044 05 5		072 59 * π		100 55 ÷	
017 85 +		045 56 *rtn		073 30 * $\sqrt{x}$		101 01 1	
018 42 STO		046 46 *LBL		074 49 *PROD		102 42 STO	
019 00 0		047 44 SUM		075 00 0		103 00 0	
020 04 4		048 43 RCL		076 03 3		104 03 3	
021 43 RCL		049 00 0		077 43 RCL		105 02 2	
022 00 0		050 04 4		078 00 0		106 95 =	
023 06 6		051 75 -		079 03 3		107 42 STO	
024 95 =		052 01 1		080 56 *rtn		108 00 0	
025 52 EE		053 95 =		081 46 *LBL		109 01 1	
026 22 INV		054 42 STO		082 11 A		110 42 STO	
027 52 EE		055 00 0		083 22 INV		111 00 0	

*Denotes 2nd function key

REGISTERS

00	05 Used	10	15
01 Used	06 Used	11	16
02 Used	07 Used	12	17
03 Used	08 Used	13	18
04 Used	09	14	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 04 4		140 56 *rtn		168 94 +/-		196 43 RCL	
113 75 -		141 46 *LBL		169 54)		197 00 0	
114 53 (		142 12 B		170 22 INV		198 01 1	
115 57 *fix		143 22 INV		171 23 lnx		199 95 =	
116 00 0		144 52 EE		172 55 ÷		200 49 *PROD	
117 75 -		145 22 INV		173 43 RCL		201 00 0	
118 93 •		146 80 *if pos		174 00 0		202 05 5	
119 05 5		147 10 *E'		175 03 3		203 43 RCL	
120 54)		148 90 *if zro		176 55 ÷		204 00 0	
121 52 EE		149 10 *E'		177 02 2		205 07 7	
122 22 INV		150 42 STO		178 45 y ^x		206 42 STO	
123 52 EE		151 00 0		179 43 RCL		207 00 0	
124 57 *fix		152 02 2		180 00 0		208 08 8	
125 09 9		153 45 y ^x		181 01 1		209 01 1	
126 95 =		154 53 (		182 95 =		210 42 STO	
127 22 INV		155 43 RCL		183 42 STO		211 00 0	
128 90 *if zro		156 00 0		184 00 0		212 06 6	
129 42 STO		157 01 1		185 04 4		213 42 STO	
130 43 RCL		158 75 -		186 42 STO		214 00 0	
131 00 0		159 01 1		187 00 0		215 04 4	
132 01 1		160 95 =		188 05 5		216 41 GTO	
133 75 -		161 65 X		189 56 *rtn		217 43 RCL	
134 01 1		162 53 (		190 46 *LBL		218 46 *LBL	
135 95 =		163 43 RCL		191 13 C		219 10 *E'	
136 29 *x!		164 00 0		192 43 RCL		220 00 0	
137 42 STO		165 02 2		193 00 0		221 20 *1/x	
138 00 0		166 55 ÷		194 02 2		222 00 0	
139 03 3		167 02 2		195 55 ÷		223 56 *rtn	

*Denotes 2nd function key

t DISTRIBUTION

The t distribution is evaluated by the following series expansion:

$$A(t|\nu) = \frac{2}{\pi} \left\{ \theta + \sin \theta \left[\cos \theta + \frac{2}{3} \cos^3 \theta + \dots + \frac{2 \cdot 4 \dots (\nu-3)}{1 \cdot 3 \dots (\nu-2)} \cos^{\nu-2} \theta \right] \right\}$$

for $\nu > 1$ and odd

$$A(t|\nu) = \frac{2\theta}{\pi} \quad \text{for } \nu=1$$

$$A(t|\nu) = \sin \theta \left[1 + \frac{1}{2} \cos^2 \theta + \frac{1 \cdot 3}{2 \cdot 4} \cos^4 \theta + \dots + \frac{1 \cdot 3 \cdot 5 \dots (\nu-3)}{2 \cdot 4 \cdot 6 \dots (\nu-2)} \cos^{\nu-2} \theta \right]$$

for ν even

Where: ν is the degrees of freedom

$$t > 0$$

$$\theta = \tan^{-1} \frac{t}{\sqrt{\nu}}$$

Then:

$$F = \frac{A(t|\nu) + 1}{2}$$

NOTES: 1. Calculations must be done in radian mode.

Example: For $t = 1.341$ and $\nu = 15$, $F = .9000625642$

Reference: *Handbook of Mathematical Functions*, Abramowitz and Stegun, National Bureau of Standards, 1964

 TEXAS INSTRUMENTS				
ST1-17		B $\rightarrow$ t DISTRIBUTION		
A $\leftarrow$ t DISTRIBUTION		ST1-17		
t	ν	F		

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Slide Deg/Rad switch to R					
3	Enter t	t	A			t
4	Enter degrees of freedom	ν	B			ν
5	Calculate F		C			F

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 30 $\sqrt{x}$		056 02 2		084 00 0	
001 11 A		029 95 =		057 75 -		085 03 3	
002 42 STO		030 22 INV		058 43 RCL		086 33 cos	
003 00 0		031 34 tan		059 00 0		087 65 X	
004 01 1		032 42 STO		060 00 0		088 02 2	
005 56 *rtn		033 00 0		061 95 =		089 55 $\div$	
006 46 *LBL		034 03 3		062 90 *if zro		090 59 π	
007 12 B		035 43 RCL		063 93 •		091 65 X	
008 42 STO		036 00 0		064 43 RCL		092 43 RCL	
009 00 0		037 00 0		065 00 0		093 00 0	
010 00 0		038 55 $\div$		066 00 0		094 04 4	
011 56 *rtn		039 02 2		067 75 -		095 85 +	
012 46 *LBL		040 75 -		068 01 1		096 02 2	
013 13 C		041 93 •		069 75 -		097 65 X	
014 01 1		042 05 5		070 90 *if zro		098 43 RCL	
015 42 STO		043 95 =		071 75 -		099 00 0	
016 00 0		044 22 INV		072 02 2		100 03 3	
017 04 4		045 52 EE		073 42 STO		101 55 $\div$	
018 42 STO		046 57 *fix		074 00 0		102 59 π	
019 00 0		047 00 0		075 06 6		103 95 =	
020 05 5		048 95 =		076 95 =		104 10 *E'	
021 43 RCL		049 52 EE		077 90 *if zro		105 56 *rtn	
022 00 0		050 22 INV		078 44 SUM		106 46 *LBL	
023 01 1		051 52 EE		079 51 SBR		107 75 -	
024 55 $\div$		052 57 *fix		080 42 STO		108 25 CLR	
025 43 RCL		053 09 9		081 46 *LBL		109 02 2	
026 00 0		054 95 =		082 65 X		110 65 X	
027 00 0		055 65 X		083 43 RCL		111 43 RCL	

*Denotes 2nd function key

REGISTERS

00 μ	05 Used	10	15
01 t	06 Used	11	16
02	07	12	17
03 Used	08	13	18
04 Used	09	14	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 00 0		140 06 6		168 00 0		196 43 RCL	
113 03 3		141 55 ÷		169 75 -		197 00 0	
114 55 ÷		142 53 (		170 03 3		198 03 3	
115 59 * π		143 43 RCL		171 75 -		199 32 sin	
116 95 =		144 00 0		172 43 RCL		200 42 STO	
117 10 *E'		145 06 6		173 00 0		201 00 0	
118 56 *rtn		146 85 +		174 06 6		202 04 4	
119 46 *LBL		147 01 1		175 95 =		203 56 *rtn	
120 93 •		148 54)		176 80 *if pos		204 46 *LBL	
121 01 1		149 65 X		177 42 STO		205 44 SUM	
122 42 STO		150 43 RCL		178 43 RCL		206 43 RCL	
123 00 0		151 00 0		179 00 0		207 00 0	
124 06 6		152 03 3		180 03 3		208 03 3	
125 51 SBR		153 33 cos		181 32 sin		209 32 sin	
126 42 STO		154 40 *x ²		182 49 *PROD		210 42 STO	
127 43 RCL		155 95 =		183 00 0		211 00 0	
128 00 0		156 42 STO		184 04 4		212 04 4	
129 04 4		157 00 0		185 43 RCL		213 41 GTO	
130 10 *E'		158 05 5		186 00 0		214 65 X	
131 56 *rtn		159 44 SUM		187 00 0		215 46 *LBL	
132 46 *LBL		160 00 0		188 75 -		216 10 *E'	
133 42 STO		161 04 4		189 02 2		217 85 +	
134 43 RCL		162 02 2		190 95 =		218 01 1	
135 00 0		163 44 SUM		191 90 *if zro		219 95 =	
136 05 5		164 00 0		192 14 D		220 55 ÷	
137 65 X		165 06 6		193 56 *rtn		221 02 2	
138 43 RCL		166 43 RCL		194 46 *LBL		222 95 =	
139 00 0		167 00 0		195 14 D		223 56 *rtn	

*Denotes 2nd function key

F DISTRIBUTION

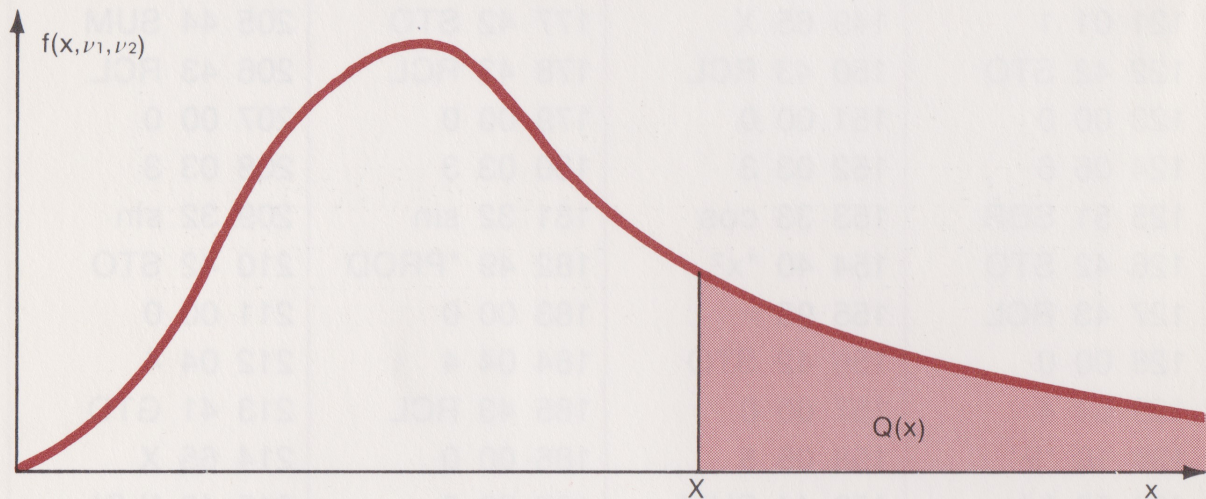
The F distribution is most commonly used in terms of the ratio of two independent variables with chi-square distributions.

If Y and Z are independent random variables distributed by chi-square laws with ν_1 and ν_2 degrees of freedom respectively, then $F = \frac{Y/\nu_1}{Z/\nu_2}$ is called the variance ratio. Its distribution is the F distribution with ν_1 and ν_2 degrees of freedom.

This program calculates $Q(x)$, the probability of an event " $x > X$ ".

$$Q(x) = \Pr\{x > X\}$$

$Q(x)$ is the "upper tail" area on the F distribution curve.



$$Q(0) = 1.0 \text{ (total area under curve} = 1.0)$$

This program calculates $Q(x)$ using series expansions, provided that either ν_1 or ν_2 is even.

Conditions: $x \geq 0$, ν_1 and ν_2 must be integers > 0 and one must be even.

$Q(x)$ is calculated according to the formulas:

1. ν_1 even

$$Q(x) = K^{\frac{\nu_2}{2}} \left[1 + \frac{\nu_2 (1-K)}{2} + \frac{\nu_2 (\nu_2+2)(1-K)^2}{2 \cdot 4} + \dots \right. \\ \left. + \frac{\nu_2 (\nu_2+2) \dots (\nu_2+\nu_1-4)(1-K)^{\frac{\nu_1-2}{2}}}{2 \cdot 4 \dots (\nu_1-2)} \right]$$

2. ν_2 even

$$Q(x) = 1 - (1-K)^{\frac{\nu_1}{2}} \left[1 + \frac{\nu_1 K}{2} + \frac{\nu_1 (\nu_1+2) K^2}{2 \cdot 4} + \dots \right. \\ \left. + \frac{\nu_1 (\nu_1+2) \dots (\nu_2+\nu_1-4) K^{\frac{\nu_2-2}{2}}}{2 \cdot 4 \dots (\nu_2-2)} \right]$$

Where: $K = \frac{1}{1 + \nu_1 x / \nu_2}$

If both ν_1 and ν_2 are even, either formula may be used. Choosing the smaller of the two will reduce computation time, since fewer terms are generated by the series expansion. For example, if $\nu_1 = 4$ and $\nu_2 = 16$, use the " ν_1 even" key **D** to calculate $Q(x)$ more quickly.

Example: For $\nu_1 = 5$, $\nu_2 = 8$: $Q(1.0) = .4748134031$, $Q(9.5) = .0032423325$

For $\nu_1 = 8$, $\nu_2 = 5$: $Q(1.0) = .5251865969$

 TEXAS INSTRUMENTS				
ST1-18		←B F DISTRIBUTION		
←A F DISTRIBUTION				ST1-18
ν_1	ν_2	x	$Q(x)_1$	$Q(x)_2$

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Inputs (in any order)	ν_1	A			ν_1
		ν_2	B			ν_2
		x	C			x
3	Compute $Q(x)$:					
	if ν_1 is even		D			$Q(x)$
	if ν_2 is even		E			$Q(x)$
4	If it is desired to					
	recall inputs		RCL	0	0	ν_1
			RCL	0	1	ν_2
			RCL	0	2	x
5	To change one or more					
	of the inputs, re-enter					
	the desired change					
	(step 2) and continue					
	to step 3.					

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 02 2		056 53 (		084 42 STO	
001 32 sin		029 44 SUM		057 53 (		085 00 0	
002 43 RCL		030 00 0		058 00 0		086 04 4	
003 00 0		031 07 7		059 42 STO		087 94 +/-	
004 09 9		032 43 RCL		060 00 0		088 85 +	
005 85 +		033 00 0		061 09 9		089 01 1	
006 53 (		034 04 4		062 43 RCL		090 54)	
007 24 CE		035 54)		063 00 0		091 45 y ^x	
008 75 -		036 42 STO		064 07 7		092 43 RCL	
009 43 RCL		037 01 1		065 55 ÷		093 01 1	
010 00 0		038 00 0		066 02 2		094 00 0	
011 06 6		039 85 +		067 65 X		095 54)	
012 85 +		040 53 (		068 42 STO		096 65 X	
013 02 2		041 43 RCL		069 01 1		097 53 (	
014 54)		042 01 1		070 00 0		098 01 1	
015 90 *if zro		043 00 0		071 02 2		099 85 +	
016 34 tan		044 65 X		072 55 ÷		100 53 (	
017 02 2		045 53 (		073 43 RCL		101 53 (	
018 54)		046 41 GTO		074 00 0		102 41 GTO	
019 42 STO		047 32 sin		075 06 6		103 32 sin	
020 00 0		048 46 *LBL		076 55 ÷		104 46 *LBL	
021 09 9		049 14 D		077 43 RCL		105 34 tan	
022 20 *1/x		050 16 *A'		078 00 0		106 54)	
023 65 X		051 46 *LBL		079 08 8		107 00 0	
024 43 RCL		052 87 *1'		080 85 +		108 95 =	
025 00 0		053 01 1		081 01 1		109 56 *rtn	
026 07 7		054 65 X		082 54)		110 46 *LBL	
027 65 X		055 53 (		083 20 *1/x		111 16 *A'	

*Denotes 2nd function key

REGISTERS

00 ν_1	05 K, 1 - K	10 Used	15
01 ν_2	06 Used	11	16
02 x	07 Used	12	17
03	08 Used	13	18
04 1 - K, K	09 Used	14	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 43 RCL		140 43 RCL		168 22 INV		196 02 2	
113 00 0		141 00 0		169 52 EE		197 30 $\sqrt{x}$	
114 00 0		142 02 2		170 52 EE		198 43 RCL	
115 42 STO		143 20 $\ast 1/x$		171 22 INV		199 00 0	
116 00 0		144 42 STO		172 52 EE		200 02 2	
117 06 6		145 00 0		173 57 $\ast \text{fix}$		201 56 $\ast \text{rtn}$	
118 43 RCL		146 08 8		174 09 9		202 00	
119 00 0		147 01 1		175 75 -		203 00	
120 02 2		148 75 -		176 43 RCL		204 00	
121 42 STO		149 53 (		177 00 0		205 00	
122 00 0		150 41 GTO		178 09 9		206 00	
123 08 8		151 87 $\ast 1'$		179 54)		207 00	
124 43 RCL		152 46 $\ast \text{LBL}$		180 30 $\ast \sqrt{x}$		208 00	
125 00 0		153 11 A		181 43 RCL		209 00	
126 01 1		154 42 STO		182 00 0		210 00	
127 42 STO		155 00 0		183 09 9		211 00	
128 00 0		156 00 0		184 56 $\ast \text{rtn}$		212 00	
129 07 7		157 46 $\ast \text{LBL}$		185 46 $\ast \text{LBL}$		213 00	
130 56 $\ast \text{rtn}$		158 24 CE		186 12 B		214 00	
131 46 $\ast \text{LBL}$		159 42 STO		187 42 STO		215 00	
132 15 E		160 00 0		188 00 0		216 00	
133 16 $\ast A$		161 09 9		189 01 1		217 00	
134 48 $\ast \text{EXC}$		162 75 -		190 41 GTO		218 00	
135 00 0		163 93 •		191 24 CE		219 00	
136 06 6		164 05 5		192 46 $\ast \text{LBL}$		220 00	
137 42 STO		165 54)		193 13 C		221 00	
138 00 0		166 57 $\ast \text{fix}$		194 42 STO		222 00	
139 07 7		167 00 0		195 00 0		223 00	

*Denotes 2nd function key

BIVARIATE NORMAL DISTRIBUTION

$$f_{(x,y)} = \frac{1}{2\pi\sigma_x\sigma_y\sqrt{1-\rho^2}} \exp \left[-\frac{\left(\frac{x-\mu_x}{\sigma_x}\right)^2 - 2\rho\left(\frac{x-\mu_x}{\sigma_x}\right)\left(\frac{y-\mu_y}{\sigma_y}\right) + \left(\frac{y-\mu_y}{\sigma_y}\right)^2}{2(1-\rho^2)} \right]$$

Where: μ_x = mean of x

μ_y = mean of y

σ_x = standard deviation of x ($\sigma_x \neq 0$)

σ_y = standard deviation of y ($\sigma_y \neq 0$)

ρ = correlation coefficient between x and y ($\rho^2 < 1$)

Error Indications: $\Sigma_x = 0$, $\sigma_y = 0$, $\rho^2 \geq 1$

Reference: *Handbook of Tables for Probability and Statistics*, edited by
W. H. Beyer, The Chemical Rubber Company, 1966

Example: $\mu_x = 1$, $\sigma_x = 1.2$

$\mu_y = 1.3$, $\sigma_y = .7$

$\rho = .5$

$f(2,1) = .0960208596$

$f(1,1.3) = .2187813077$

 TEXAS INSTRUMENTS				
ST1-19		B BIVARIATE NORMAL DIST		
A BIVARIATE NORMAL DIST				ST1-19
x	y	f(x,y)		
μ_x	σ_x	μ_y	σ_y	ρ

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Enter μ_x	μ_x	A			μ_x
3	Enter σ_x	σ_x	B			σ_x
4	Enter μ_y	μ_y	C			μ_y
5	Enter σ_y	σ_y	D			σ_y
6	Enter ρ	ρ	E			ρ
7	Enter x	x	2nd	A'		x
8	Enter y	y	2nd	B'		y
9	Calculate f(x,y)		2nd	C'		f(x,y)

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 43 RCL		056 00 0		084 00 0	
001 11 A		029 00 0		057 06 6		085 03 3	
002 42 STO		030 03 3		058 75 -		086 95 =	
003 00 0		031 56 *rtn		059 43 RCL		087 48 *EXC	
004 00 0		032 46 *LBL		060 00 0		088 00 0	
005 56 *rtn		033 15 E		061 00 0		089 07 7	
006 46 *LBL		034 42 STO		062 95 =		090 56 *rtn	
007 12 B		035 00 0		063 55 ÷		091 46 *LBL	
008 42 STO		036 04 4		064 43 RCL		092 18 *C'	
009 00 0		037 40 *x ²		065 00 0		093 43 RCL	
010 01 1		038 94 +/-		066 01 1		094 00 0	
011 20 *1/x		039 85 +		067 95 =		095 06 6	
012 43 RCL		040 01 1		068 48 *EXC		096 40 *x ²	
013 00 0		041 95 =		069 00 0		097 75 -	
014 01 1		042 22 INV		070 06 6		098 02 2	
015 56 *rtn		043 80 *if pos		071 56 *rtn		099 65 X	
016 46 *LBL		044 52 EE		072 46 *LBL		100 43 RCL	
017 13 C		045 42 STO		073 17 *B'		101 00 0	
018 42 STO		046 00 0		074 42 STO		102 04 4	
019 00 0		047 05 5		075 00 0		103 65 X	
020 02 2		048 20 *1/x		076 07 7		104 43 RCL	
021 56 *rtn		049 43 RCL		077 75 -		105 00 0	
022 46 *LBL		050 00 0		078 43 RCL		106 06 6	
023 14 D		051 04 4		079 00 0		107 65 X	
024 42 STO		052 56 *rtn		080 02 2		108 43 RCL	
025 00 0		053 46 *LBL		081 95 =		109 00 0	
026 03 3		054 16 *A'		082 55 ÷		110 07 7	
027 20 *1/x		055 42 STO		083 43 RCL		111 85 +	

*Denotes 2nd function key

REGISTERS

00 μ_x	05 Used	10	15
01 σ_x	06 Used	11	16
02 μ_y	07 Used	12	17
03 σ_y	08	13	18
04 ρ	09	14	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 43 RCL		140 55 ÷		168 00		196 00	
113 00 0		141 43 RCL		169 00		197 00	
114 07 7		142 00 0		170 00		198 00	
115 40 *x ²		143 03 3		171 00		199 00	
116 95 =		144 95 =		172 00		200 00	
117 55 ÷		145 56 *rtn		173 00		201 00	
118 02 2		146 46 *LBL		174 00		202 00	
119 55 ÷		147 52 EE		175 00		203 00	
120 43 RCL		148 23 Inx		176 00		204 00	
121 00 0		149 43 RCL		177 00		205 00	
122 05 5		150 00 0		178 00		206 00	
123 95 =		151 04 4		179 00		207 00	
124 94 +/-		152 56 *rtn		180 00		208 00	
125 22 INV		153 00		181 00		209 00	
126 23 Inx		154 00		182 00		210 00	
127 55 ÷		155 00		183 00		211 00	
128 43 RCL		156 00		184 00		212 00	
129 00 0		157 00		185 00		213 00	
130 05 5		158 00		186 00		214 00	
131 30 *√x		159 00		187 00		215 00	
132 55 ÷		160 00		188 00		216 00	
133 02 2		161 00		189 00		217 00	
134 55 ÷		162 00		190 00		218 00	
135 59 *π		163 00		191 00		219 00	
136 55 ÷		164 00		192 00		220 00	
137 43 RCL		165 00		193 00		221 00	
138 00 0		166 00		194 00		222 00	
139 01 1		167 00		195 00		223 00	

*Denotes 2nd function key

LOGARITHMIC NORMAL DISTRIBUTION

$$f(x) = \frac{1}{x\sqrt{2\pi\sigma^2}} \exp \left[-\frac{(\ln x - m)^2}{2\sigma^2} \right]$$

Where: x is a random variable whose logarithm is normally distributed with mean m and variance σ^2 . ($x > 0$, $\sigma^2 \neq 0$)

For given m and σ^2 , the following are computed:

$$\text{median} = e^m$$

$$\text{mode} = e^{(m - \sigma^2)}$$

$$\text{mean} = e^{(m + \sigma^2/2)}$$

$$\text{variance} = e^{(\sigma^2 + 2m)}(e^{\sigma^2} - 1)$$

$$f(x)$$

Reference: *Handbook of Probability and Statistics with Tables*,
Burlington and May, McGraw-Hill

Example: $m = 2$, $\sigma^2 = 1.5$

$$\text{median} = 7.389056099$$

$$\text{mode} = 1.648721271$$

$$\text{mean} = 15.64263188$$

$$\text{variance} = 851.9412262$$

$$f(.01) = .0000157407$$

$$f(.5) = .058064287$$

$$f(1.0) = .0858628159$$

 TEXAS INSTRUMENTS				
◀A LOGARITHMIC NORMAL DIST ST1-20				
m → med	σ ² → mode	mean	variance	x → f(x)

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A only)					
2	Compute median	m	A			median
3	Compute mode	σ ²	B			mode
4	Compute mean		C			mean
5	Compute variance		D			variance
6		x	E			f(x)
	Repeat step 6 for					
	additional values of x					

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 00 0		056 95 =		084 55 ÷	
001 11 A		029 02 2		057 22 INV		085 43 RCL	
002 42 STO		030 95 =		058 23 Inx		086 00 0	
003 00 0		031 56 *rtn		059 65 X		087 01 1	
004 00 0		032 46 *LBL		060 53 (		088 95 =	
005 22 INV		033 13 C		061 43 RCL		089 22 INV	
006 23 Inx		034 43 RCL		062 00 0		090 23 Inx	
007 42 STO		035 00 0		063 03 3		091 55 ÷	
008 00 0		036 01 1		064 75 -		092 43 RCL	
009 02 2		037 55 ÷		065 01 1		093 00 0	
010 56 *rtn		038 02 2		066 54)		094 04 4	
011 46 *LBL		039 95 =		067 95 =		095 55 ÷	
012 12 B		040 22 INV		068 56 *rtn		096 53 (	
013 42 STO		041 23 Inx		069 46 *LBL		097 02 2	
014 00 0		042 16 *A'		070 15 E		098 65 X	
015 01 1		043 56 *rtn		071 42 STO		099 59 * π	
016 22 INV		044 46 *LBL		072 00 0		100 65 X	
017 23 Inx		045 14 D		073 04 4		101 43 RCL	
018 42 STO		046 43 RCL		074 23 Inx		102 00 0	
019 00 0		047 00 0		075 75 -		103 01 1	
020 03 3		048 00 0		076 43 RCL		104 54)	
021 20 *1/x		049 65 X		077 00 0		105 30 * $\sqrt{x}$	
022 16 *A'		050 02 2		078 00 0		106 95 =	
023 56 *rtn		051 95 =		079 95 =		107 56 *rtn	
024 46 *LBL		052 85 +		080 40 * x^2		108 00	
025 16 *A'		053 43 RCL		081 94 +/-		109 00	
026 65 X		054 00 0		082 55 ÷		110 00	
027 43 RCL		055 01 1		083 02 2		111 00	

*Denotes 2nd function key

REGISTERS

00 m	05	10	15
01 σ^2	06	11	16
02 e^m	07	12	17
03 e^{σ^2}	08	13	18
04 X	09	14	19

FLAGS

0	1	2	3	4
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WEIBULL DISTRIBUTION

This program can be used to calculate:

1. $f(x_1) = mnx^{(n-1)}e^{(-mx^n)}$

Where $m > 0, n > 0, x > 0$

2. $Q(x_1) = e^{(-mx^n)}$

3. x_2 for a given $Q, Q > 0$, such that

$$x_2 = \left(-\frac{\ln Q(x_2)}{m} \right)^{1/n}$$

Example: $m = .2, n = .9$

$$f(2) = .1156338734$$

$$Q(2) = .6885184274$$

$$\text{if } Q(x_2) = .75, x_2 = 1.497701748$$

 TEXAS INSTRUMENTS				
				B
WEIBULL DISTRIBUTION				ST1-21
m	n	$x_1 \rightarrow f(x_1)$	$Q(x_1)$	$Q(x_2) \rightarrow x_2'$

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A only)					
2	Enter m	m	A			m
3	Enter n	n	B			n
4	Compute $f(x_1)$	x_1	C			$f(x_1)$
5	Compute $Q(x_1)$		D			$Q(x_1)$
6	Compute x_2	$Q(x_2)$	E			x_2

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 06 6		056 95 =		084 07 7	
001 11 A		029 65 X		057 94 +/-		085 20 *1/x	
002 42 STO		030 43 RCL		058 65 X		086 95 =	
003 00 0		031 00 0		059 43 RCL		087 56 *rtn	
004 06 6		032 07 7		060 00 0		088 46 *LBL	
005 22 INV		033 65 X		061 06 6		089 87 *1'	
006 80 *if pos		034 53 (		062 95 =		090 25 CLR	
007 87 *1'		035 43 RCL		063 22 INV		091 20 *1/x	
008 56 *rtn		036 00 0		064 23 ln x		092 56 *rtn	
009 46 *LBL		037 08 8		065 56 *rtn		093 00	
010 12 B		038 45 y ^x		066 46 *LBL		094 00	
011 42 STO		039 53 (		067 14 D		095 00	
012 00 0		040 43 RCL		068 51 SBR		096 00	
013 07 7		041 00 0		069 33 cos		097 00	
014 22 INV		042 07 7		070 56 *rtn		098 00	
015 80 *if pos		043 75 -		071 46 *LBL		099 00	
016 87 *1'		044 01 1		072 15 E		100 00	
017 56 *rtn		045 95 =		073 23 ln x		101 00	
018 46 *LBL		046 56 *rtn		074 94 +/-		102 00	
019 13 C		047 46 *LBL		075 55 ÷		103 00	
020 42 STO		048 33 cos		076 43 RCL		104 00	
021 00 0		049 43 RCL		077 00 0		105 00	
022 08 8		050 00 0		078 06 6		106 00	
023 51 SBR		051 08 8		079 95 =		107 00	
024 33 cos		052 45 y ^x		080 45 y ^x		108 00	
025 65 X		053 43 RCL		081 53 (		109 00	
026 43 RCL		054 00 0		082 43 RCL		110 00	
027 00 0		055 07 7		083 00 0		111 00	

*Denotes 2nd function key

REGISTERS

00	05	10	15
01	06 m	11	16
02	07 n	12	17
03	08 x ₁	13	18
04	09	14	19

FLAGS

0	1	2	3	4
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POISSON DISTRIBUTION

This program calculates the density function $f(x)$ and the cumulative distribution $P(x)$.

$$f(x) = \frac{m^x e^{-m}}{x!}$$

$$P(x) = \sum_{k=0}^x f(k)$$

Where: $m > 0$

$x = 0, 1, 2, \dots$

Reference: *Handbook of Tables for Probability and Statistics*, edited by W. H. Beyer, The Chemical Rubber Company, 1966

Example: $m = 2.7$

$f(0) = .0672055127$

$f(8) = .0047075451$

$P(8) = .9980863725$

TEXAS INSTRUMENTS				
POISSON DISTRIBUTION				ST1-22
$m \rightarrow f(0)$	$x \rightarrow f(x)$	$P(x)$		

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A only)					
2	Compute $f(0)$	m	A			$f(0)$
3	Compute $f(x)$	x	B			$f(x)$
4	Compute $P(x)$		C			$P(x)$

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 06 6		056 00 0		084 44 SUM	
001 11 A		029 09 9		057 00 0		085 00 0	
002 42 STO		030 95 =		058 75 -		086 02 2	
003 00 0		031 80 *if pos		059 43 RCL		087 01 1	
004 01 1		032 89 *3'		060 00 0		088 44 SUM	
005 23 Inx		033 85 +		061 04 4		089 00 0	
006 43 RCL		034 06 6		062 95 =		090 00 0	
007 00 0		035 09 9		063 90 *if zro		091 41 GTO	
008 01 1		036 95 =		064 32 sin		092 87 *1'	
009 70 *if err		037 29 *x!		065 43 RCL		093 46 *LBL	
010 88 *2'		038 70 *if err		066 00 0		094 34 tan	
011 94 +/-		039 34 tan		067 01 1		095 43 RCL	
012 22 INV		040 43 RCL		068 55 ÷		096 00 0	
013 23 Inx		041 00 0		069 53 (		097 04 4	
014 42 STO		042 05 5		070 43 RCL		098 56 *rtn	
015 00 0		043 42 STO		071 00 0		099 46 *LBL	
016 05 5		044 00 0		072 00 0		100 32 sin	
017 46 *LBL		045 03 3		073 85 +		101 43 RCL	
018 88 *2'		046 42 STO		074 01 1		102 00 0	
019 56 *rtn		047 00 0		075 54)		103 03 3	
020 46 *LBL		048 02 2		076 65 X		104 56 *rtn	
021 12 B		049 00 0		077 43 RCL		105 46 *LBL	
022 42 STO		050 42 STO		078 00 0		106 13 C	
023 00 0		051 00 0		079 03 3		107 43 RCL	
024 04 4		052 00 0		080 95 =		108 00 0	
025 46 *LBL		053 46 *LBL		081 42 STO		109 02 2	
026 89 *3'		054 87 *1'		082 00 0		110 56 *rtn	
027 75 -		055 43 RCL		083 03 3		111 00	

*Denotes 2nd function key

REGISTERS

00 Used	05 Used	10	15
01 m	06	11	16
02 P(x)	07	12	17
03 f(x)	08	13	18
04 x	09	14	19

FLAGS

0	1	2	3	4
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BINOMIAL DISTRIBUTION

This program evaluates the binomial density function defined by

$$f(k;n,p) = \binom{n}{k} p^k q^{(n-k)} \quad \begin{array}{l} n = 1, 2, \dots \\ 0 < p < 1 \\ q = (1-p) \\ k = 0, 1, 2, \dots, n \end{array}$$

With mean: $m = np$ and variance $\sigma^2 = npq$

Where: p = probability of success on each trial
 q = probability of failure

For a given k , n , and p , the function $f(k;n,p)$ gives the probability of k successes and $(n-k)$ failures, without regard to their order of occurrence, in n trials of an experiment.

Results of the evaluation are:

$$\begin{array}{l} f(k;n,p) \\ m \\ \sigma^2 \end{array}$$

and the cumulative distribution

$$P(k) = \sum_{k'=0}^k \binom{n}{k'} p^{k'} q^{n-k'}$$

Which is the probability of observing k or less successes in n trials, and

$$P'(k) = \sum_{k=k'}^n \binom{n}{k} p^k q^{n-k}$$

which gives the probability of observing at least k' successes in n trials.

For simplicity, $f(k; n, p)$ is written as $f(k)$.

With $k = 0$

$$f(k) = f(0) = q^n$$

For $k > 0$

$$f(k) = \frac{p^{(n-k)}}{kq} f(k-1)$$

Reference: *An Introduction to Probability Theory and Its Applications*,
 William Feller, John Wiley & Sons, 1968

Example: $n = 7$ $p = 0.45$ $k = 5$

$$\begin{array}{ll} m &= 3.15 \\ \sigma^2 &= 1.7325 \\ f(5) &= .1172214914 \\ P(5) &= .9642938078 \\ P'(5) &= .1529276836 \end{array}$$

 TEXAS INSTRUMENTS				
ST1-23		←A B→ BINOMIAL DISTRIBUTION		
←A B→ BINOMIAL DISTRIBUTION				ST1-23
			P'(k)	P(k)
INIT	n	p	σ^2	k → f(k)

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Initialize		A			0.
3	Enter n	n	B			n
4	Compute mean	p	C			m
5	Compute variance		D			σ^2
6	Compute f(k)	k	E			f(k)
7	Compute P(k)		2nd	E'		P(k)
8	Compute P'(k)		2nd	D'		P'(k)
	Repeat 6,7,8 for					
	new value of k.					

Note: All 9's (flashing) in the display following a data entry, indicates invalid data entry.

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 56 *rtn		028 42 STO		056 87 *1'		084 44 SUM	
001 46 *LBL		029 00 0		057 43 RCL		085 01 1	
002 15 E		030 08 8		058 00 0		086 01 1	
003 22 INV		031 42 STO		059 02 2		087 94 +/—	
004 80 *if pos		032 00 0		060 65 X		088 44 SUM	
005 80 *if pos		033 09 9		061 43 RCL		089 01 1	
006 42 STO		034 43 RCL		062 01 1		090 00 0	
007 00 0		035 00 0		063 00 0		091 58 *dsz	
008 06 6		036 06 6		064 65 X		092 87 *1'	
009 43 RCL		037 90 *if zro		065 43 RCL		093 46 *LBL	
010 00 0		038 89 *3'		066 00 0		094 89 *3'	
011 01 1		039 01 1		067 08 8		095 00 0	
012 75 —		040 42 STO		068 55 ÷		096 42 STO	
013 43 RCL		041 01 1		069 43 RCL		097 01 1	
014 00 0		042 01 1		070 01 1		098 00 0	
015 06 6		043 43 RCL		071 01 1		099 42 STO	
016 95 =		044 00 0		072 55 ÷		100 01 1	
017 22 INV		045 06 6		073 43 RCL		101 01 1	
018 80 *if pos		046 42 STO		074 00 0		102 43 RCL	
019 80 *if pos		047 00 0		075 03 3		103 00 0	
020 43 RCL		048 00 0		076 95 =		104 08 8	
021 00 0		049 43 RCL		077 42 STO		105 56 *rtn	
022 03 3		050 00 0		078 00 0		106 46 *LBL	
023 45 y^x		051 01 1		079 08 8		107 11 A	
024 43 RCL		052 42 STO		080 44 SUM		108 25 CLR	
025 00 0		053 01 1		081 00 0		109 47 *CMs	
026 01 1		054 00 0		082 09 9		110 86 *rset	
027 95 =		055 46 *LBL		083 01 1		111 46 *LBL	

REGISTERS

00	05 σ^2	10 current (k - 1)	15
01 n	06 k	11 current (k)	16
02 p	07 (n - k)	12	17
03 q	08 f(k)	13	18
04 m	09 P(k)	14	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 12 B		140 00 0		168 00 0		196 46 *LBL	
113 22 INV		141 02 2		169 03 3		197 80 *if pos	
114 80 *if pos		142 94 +/—		170 95 =		198 00 0	
115 80 *if pos		143 85 +		171 42 STO		199 20 *1/x	
116 90 *if zro		144 01 1		172 00 0		200 56 *rtn	
117 80 *if pos		145 95 =		173 05 5		201 00	
118 42 STO		146 42 STO		174 56 *rtn		202 00	
119 00 0		147 00 0		175 46 *LBL		203 00	
120 01 1		148 03 3		176 10 *E'		204 00	
121 56 *rtn		149 43 RCL		177 43 RCL		205 00	
122 46 *LBL		150 00 0		178 00 0		206 00	
123 13 C		151 01 1		179 09 9		207 00	
124 22 INV		152 65 X		180 56 *rtn		208 00	
125 80 *if pos		153 43 RCL		181 46 *LBL		209 00	
126 80 *if pos		154 00 0		182 19 *D'		210 00	
127 42 STO		155 02 2		183 43 RCL		211 00	
128 00 0		156 95 =		184 00 0		212 00	
129 02 2		157 42 STO		185 09 9		213 00	
130 01 1		158 00 0		186 75 —		214 00	
131 75 —		159 04 4		187 43 RCL		215 00	
132 43 RCL		160 56 *rtn		188 00 0		216 00	
133 00 0		161 46 *LBL		189 08 8		217 00	
134 02 2		162 14 D		190 95 =		218 00	
135 95 =		163 43 RCL		191 94 +/—		219 00	
136 22 INV		164 00 0		192 85 +		220 00	
137 80 *if pos		165 04 4		193 01 1		221 00	
138 80 *if pos		166 65 X		194 95 =		222 00	
139 43 RCL		167 43 RCL		195 56 *rtn		223 00	

NEGATIVE BINOMIAL DISTRIBUTION

This program evaluates the negative binomial density function defined by

$$f(k; r, p) = \binom{r+k-1}{k} p^r q^k \quad \begin{array}{l} r = 1, 2, \dots, \geq k \\ 0 < p < 1 \\ q = (1 - p) \\ k = 0, 1, 2, \dots \end{array}$$

With mean: $m = \frac{rq}{p}$ and variance $\sigma^2 = \frac{rq}{p^2}$

Where: p = probability of success at each trial
 q = probability of failure

For a given k , r , and p , the function $f(k; r, p)$ gives the probability that exactly k failures precede the r th success.

Results of the evaluation are:

$$f(k; r, p)$$

$$m$$

$$\sigma^2$$

and the cumulative distribution

$$P(k) = \sum_{k'=0}^k \binom{r+k'-1}{k'} p^r q^{k'}$$

which is the probability of observing k or less successes in $r + k$ trials, and

$$P'(k) = \sum_{k=k'}^{r+k} \binom{r+k-1}{k} p^r q^k$$

which gives the probability that there are at least k successes in $r + k$ trials.

For simplicity, $f(k; r, p)$ is written as $f(k)$.

With $k = 0$

$$f(k) = f(0) = p^r$$

For $k > 0$

$$f(k) = \frac{q[(k-1) + r]}{k} f(k-1)$$

Reference: *An Introduction to Probability Theory and Its Applications*, William Feller, John Wiley & Sons, 1968

Example: $r = 5$ $p = 0.9$ $k = 3$

$$m = .5555555556$$

$$\sigma^2 = .6172839506$$

$$f(3) = 0.02066715$$

$$P(3) = 0.99497565$$

$$P'(3) = 0.0256915$$

 TEXAS INSTRUMENTS				
ST1-24		►B NEGATIVE BINOMIAL DIST		
◄A		NEGATIVE BINOMIAL DIST		ST1-24
			P'(k)	P(k)
INIT	r	p → m	σ^2	k → f(k)

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Initialize		A			0.
3	Enter r	r	B			r
4	Compute mean	p	C			m
5	Compute variance		D			σ^2
6	Compute f(k)	k	E			f(k)
7	Compute P(k)		2nd	E'		P(k)
8	Compute P'(k)		2nd	D'		P'(k)
	Repeat 6, 7, 8 for					
	new value of k					

Note: All 9's (flashing) in the display following a data entry indicates invalid data entry.

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 56 *rtn		028 42 STO		056 87 *1'		084 01 1	
001 46 *LBL		029 00 0		057 43 RCL		085 01 1	
002 15 E		030 08 8		058 00 0		086 58 *dsz	
003 22 INV		031 42 STO		059 03 3		087 87 *1'	
004 80 *if pos		032 00 0		060 65 X		088 46 *LBL	
005 80 *if pos		033 09 9		061 43 RCL		089 89 *3'	
006 42 STO		034 43 RCL		062 00 0		090 00 0	
007 00 0		035 00 0		063 08 8		091 42 STO	
008 06 6		036 06 6		064 55 ÷		092 01 1	
009 43 RCL		037 90 *if zro		065 43 RCL		093 00 0	
010 00 0		038 89 *3'		066 01 1		094 42 STO	
011 01 1		039 01 1		067 01 1		095 01 1	
012 75 -		040 42 STO		068 65 X		096 01 1	
013 43 RCL		041 01 1		069 43 RCL		097 43 RCL	
014 00 0		042 01 1		070 01 1		098 00 0	
015 06 6		043 43 RCL		071 00 0		099 08 8	
016 95 =		044 00 0		072 95 =		100 56 *rtn	
017 22 INV		045 06 6		073 42 STO		101 46 *LBL	
018 80 *if pos		046 42 STO		074 00 0		102 11 A	
019 80 *if pos		047 00 0		075 08 8		103 25 CLR	
020 43 RCL		048 00 0		076 44 SUM		104 47 *CMs	
021 00 0		049 43 RCL		077 00 0		105 57 *fix	
022 02 2		050 00 0		078 09 9		106 09 9	
023 45 y ^x		051 01 1		079 01 1		107 86 *rset	
024 43 RCL		052 42 STO		080 44 SUM		108 46 *LBL	
025 00 0		053 01 1		081 01 1		109 12 B	
026 01 1		054 00 0		082 00 0		110 22 INV	
027 95 =		055 46 *LBL		083 44 SUM		111 80 *if pos	

*Denotes 2nd function key

REGISTERS

00	05 σ^2	10 P'(k)	15
01 r	06 k	11 current (k - 1)	16
02 p	07 (k + r)	12 current k	17
03 q	08 f(k)	13	18
04 m	09 P(k)	14	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 80	*if pos	140 85	+	168 43	RCL	196 56	*rtn
113 90	*if zro	141 01	1	169 00	0	197 46	*LBL
114 80	*if pos	142 95	=	170 02	2	198 80	*if pos
115 42	STO	143 42	STO	171 95	=	199 00	0
116 00	0	144 00	0	172 42	STO	200 20	*1/x
117 01	1	145 03	3	173 00	0	201 56	*rtn
118 56	*rtn	146 43	RCL	174 05	5	202 00	
119 46	*LBL	147 00	0	175 56	*rtn	203 00	
120 13	C	148 01	1	176 46	*LBL	204 00	
121 22	INV	149 65	X	177 10	*E'	205 00	
122 80	*if pos	150 43	RCL	178 43	RCL	206 00	
123 80	*if pos	151 00	0	179 00	0	207 00	
124 42	STO	152 03	3	180 09	9	208 00	
125 00	0	153 55	÷	181 56	*rtn	209 00	
126 02	2	154 43	RCL	182 46	*LBL	210 00	
127 01	1	155 00	0	183 19	*D'	211 00	
128 75	—	156 02	2	184 43	RCL	212 00	
129 43	RCL	157 95	=	185 00	0	213 00	
130 00	0	158 42	STO	186 09	9	214 00	
131 02	2	159 00	0	187 75	—	215 00	
132 95	=	160 04	4	188 43	RCL	216 00	
133 22	INV	161 56	*rtn	189 00	0	217 00	
134 80	*if pos	162 46	*LBL	190 08	8	218 00	
135 80	*if pos	163 14	D	191 95	=	219 00	
136 43	RCL	164 43	RCL	192 94	+/-	220 00	
137 00	0	165 00	0	193 85	+	221 00	
138 02	2	166 04	4	194 01	1	222 00	
139 94	+/-	167 55	÷	195 95	=	223 00	

*Denotes 2nd function key

GEOMETRIC DISTRIBUTION

For a geometric distribution with mean μ , this program will calculate:

1. p , the probability of an event occurring
2. the variance $\sigma^2 = \frac{1-p}{p^2}$
3. $f(x) = p(1-p)^x$
4. the cumulative distribution $P(x) = 1 - (1-p)^{x+1}$

Where: $0 \leq p \leq 1$.

Error Indications: A negative mean or x will cause the display to flash 9.999999999 99 and those values will be ignored.

Reference: *Handbook of Probability and Statistics with Tables*,
Burlington and May, McGraw-Hill

Example: $\mu = 4.2$ $x = 3$

$$p = .1923076923$$

$$\sigma^2 = 21.84$$

$$f(3) = .1013291726$$

$$P(3) = .5744174749$$

 TEXAS INSTRUMENTS				
◀B▶				
◀A▶ GEOMETRIC DISTRIBUTION				ST1-25
$\mu \rightarrow p$	σ^2	$x \rightarrow f(x)$	$P(x)$	

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A only)					
2	Compute probability	μ	A			p
3	Compute variance		B			σ^2
4	Compute $f(x)$	x	C			$f(x)$
5	Compute $P(x)$		D			$P(x)$

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 42 STO		056 95 =		084 00	
001 11 A		029 00 0		057 56 *rtn		085 00	
002 22 INV		030 01 1		058 46 *LBL		086 00	
003 80 *if pos		031 16 *A'		059 16 *A'		087 00	
004 87 *1'		032 45 y ^x		060 01 1		088 00	
005 85 +		033 43 RCL		061 75 -		089 00	
006 01 1		034 00 0		062 43 RCL		090 00	
007 95 =		035 01 1		063 00 0		091 00	
008 20 *1/x		036 65 X		064 00 0		092 00	
009 42 STO		037 43 RCL		065 95 =		093 00	
010 00 0		038 00 0		066 56 *rtn		094 00	
011 00 0		039 00 0		067 46 *LBL		095 00	
012 56 *rtn		040 95 =		068 87 *1'		096 00	
013 46 *LBL		041 56 *rtn		069 25 CLR		097 00	
014 12 B		042 46 *LBL		070 20 *1/x		098 00	
015 16 *A'		043 14 D		071 56 *rtn		099 00	
016 55 ÷		044 16 *A'		072 00		100 00	
017 43 RCL		045 45 y ^x		073 00		101 00	
018 00 0		046 53 (		074 00		102 00	
019 00 0		047 43 RCL		075 00		103 00	
020 40 *x ²		048 00 0		076 00		104 00	
021 95 =		049 01 1		077 00		105 00	
022 56 *rtn		050 85 +		078 00		106 00	
023 46 *LBL		051 01 1		079 00		107 00	
024 13 C		052 95 =		080 00		108 00	
025 22 INV		053 94 +/-		081 00		109 00	
026 80 *if pos		054 85 +		082 00		110 00	
027 87 *1'		055 01 1		083 00		111 00	

*Denotes 2nd function key

REGISTERS

00 P	05	10	15
01 X	06	11	16
02	07	12	17
03	08	13	18
04	09	14	19

FLAGS

0	1	2	3	4
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HYPERGEOMETRIC DISTRIBUTION

This program evaluates the hypergeometric density function for given a , b , n :

$$f(x) = \frac{({}_a C_x)({}_b C_{n-x})}{({}_{a+b} C_n)}$$

Where: a , b , n are positive integers ≤ 69

$$a + b \leq 69$$

$$x \leq a, b - n + x \leq 69$$

$$x = 0, 1, 2, \dots, 69$$

using the relation

$$f(p+1) = \frac{(p-a)(p-n)}{(p+1)(b-n+p+1)} f(p)$$

$$p = 0, 1, 2, \dots, (x-1)$$

to find the cumulative distribution

$$P(x) = \sum_{p=0}^{x-1} f(p)$$

The mean and variance are found using

$$m = \frac{an}{a+b}$$

$$\sigma^2 = \frac{abn(a+b-n)}{(a+b)^2(a+b-1)}$$

Example: $a = 10$ $b = 8$ $n = 7$

$$f(0) = P(0) = .0002513826$$

$$f(4) = .3695324284 \quad P(4) = .721719457$$

$$f(7) = .0037707391 \quad P(7) = 1.$$

$$m = 3.888888889$$

$$\sigma^2 = 1.118373275$$

 TEXAS INSTRUMENTS				
ST1-26		B ▶ HYPERGEOMETRIC DIST		
◀ A HYPERGEOMETRIC DIST				ST1-26
a,b	$n \rightarrow f(0)$	$x \rightarrow f(x)$	P(x)	m, σ^2

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Enter a	a	A			a *
3	Enter b	b	RUN			b *
4	Compute f(0)	n	B			f(0)*
5	Compute f(x)	x	C			f(x)*
6	Compute P(x)		D			P(x)
7	Compute mean		E			m
8	Compute variance		RUN			σ^2
9	For new x, go to 5.					
	For new n, go to 4.					
	For new a,b go to 2.					
10	To compute m, σ^2 for					
	new a,b perform					
	2, 3, 7, and 8.					

*Error indications after:

Step 2 if $a < 0$, $a > 69$, or non-integral

Step 3 if $b < 0$, $b > 69$, b non-integral, or $a+b > 69$

Step 4 if $n < 0$, $n > 69$, or non-integral

Step 5 if $x < 0$, $x > 69$, or non-integral

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46 *LBL		028 03 3		056 55 ÷		084 16 *A'	
001 19 *D'		029 18 *C'		057 53 (		085 42 STO	
002 43 RCL		030 16 *A'		058 43 RCL		086 00 0	
003 00 0		031 43 RCL		059 00 0		087 05 5	
004 00 0		032 00 0		060 02 2		088 01 1	
005 56 *rtn		033 02 2		061 75 -		089 94 +/-	
006 46 *LBL		034 56 *rtn		062 43 RCL		090 42 STO	
007 18 *C'		035 46 *LBL		063 00 0		091 00 0	
008 43 RCL		036 12 B		064 04 4		092 00 0	
009 00 0		037 16 *A'		065 54)		093 43 RCL	
010 03 3		038 42 STO		066 29 *x!		094 00 0	
011 56 *rtn		039 00 0		067 95 =		095 08 8	
012 46 *LBL		040 04 4		068 42 STO		096 42 STO	
013 11 A		041 94 +/-		069 00 0		097 00 0	
014 16 *A'		042 85 +		070 08 8		098 07 7	
015 42 STO		043 18 *C'		071 56 *rtn		099 46 *LBL	
016 00 0		044 46 *LBL		072 46 *LBL		100 24 CE	
017 01 1		045 52 EE		073 16 *A'		101 42 STO	
018 42 STO		046 95 =		074 42 STO		102 00 0	
019 00 0		047 29 *x!		075 00 0		103 06 6	
020 03 3		048 55 ÷		076 00 0		104 01 1	
021 56 *rtn		049 18 *C'		077 29 *x!		105 44 SUM	
022 16 *A'		050 29 *x!		078 19 *D'		106 00 0	
023 42 STO		051 65 X		079 70 *if err		107 00 0	
024 00 0		052 43 RCL		080 52 EE		108 19 *D'	
025 02 2		053 00 0		081 56 *rtn		109 75 -	
026 44 SUM		054 02 2		082 46 *LBL		110 43 RCL	
027 00 0		055 29 *x!		083 13 C		111 00 0	

*Denotes 2nd function key

REGISTERS

00 Used	05 x	10	15
01 a	06 f(x)	11	16
02 b	07 P(x)	12	17
03 a + b	08 Used	13	18
04 n	09	14	19

FLAGS

0	1	2	3	4
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PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 05 5		140 54)		168 14 D		196 01 1	
113 95 =		141 55 ÷		169 43 RCL		197 54)	
114 90 *if zro		142 53 (		170 00 0		198 95 =	
115 32 sin		143 19 *D'		171 07 7		199 56 *rtn	
116 43 RCL		144 85 +		172 56 *rtn		200 46 *LBL	
117 00 0		145 01 1		173 46 *LBL		201 17 *B'	
118 06 6		146 85 +		174 15 E		202 43 RCL	
119 65 X		147 43 RCL		175 17 *B'		203 00 0	
120 53 (		148 00 0		176 56 *rtn		204 01 1	
121 19 *D'		149 02 2		177 17 *B'		205 65 X	
122 75 -		150 75 -		178 65 X		206 43 RCL	
123 43 RCL		151 43 RCL		179 43 RCL		207 00 0	
124 00 0		152 00 0		180 00 0		208 04 4	
125 01 1		153 04 4		181 02 2		209 55 ÷	
126 54)		154 54)		182 65 X		210 18 *C'	
127 65 X		155 95 =		183 53 (		211 95 =	
128 53 (		156 44 SUM		184 18 *C'		212 56 *rtn	
129 19 *D'		157 00 0		185 75 -		213 00 0	
130 75 -		158 07 7		186 43 RCL		214 00 0	
131 43 RCL		159 41 GTO		187 00 0		215 00 0	
132 00 0		160 24 CE		188 04 4		216 00 0	
133 04 4		161 46 *LBL		189 54)		217 00 0	
134 54)		162 32 sin		190 55 ÷		218 00 0	
135 55 ÷		163 43 RCL		191 18 *C'		219 00 0	
136 53 (		164 00 0		192 55 ÷		220 00 0	
137 19 *D'		165 06 6		193 53 (		221 00 0	
138 85 +		166 56 *rtn		194 18 *C'		222 00 0	
139 01 1		167 46 *LBL		195 75 -		223 00 0	

*Denotes 2nd function key

TEXAS INSTRUMENTS
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DALLAS, TEXAS 75222